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PREHISPANIC AGRICULTURAL SYSTEMS IN THE CHICAMA VALLEY

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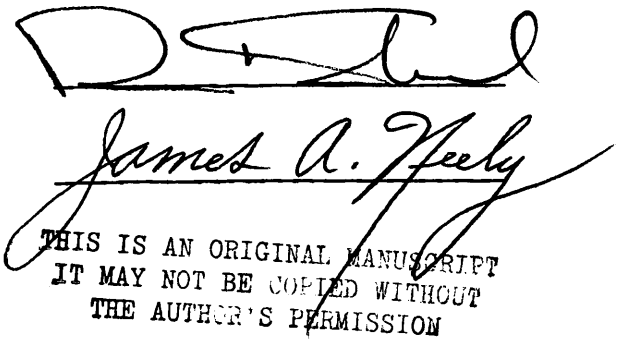

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WATER CONTROL AND LAND USE ON THE ARID NORTH COAST OF PERU: PREHISPANIC AGRICULTURAL SYSTEMS IN THE CHICAMA VALLEY

BY

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THESIS

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"As I practised conjecture more, I learned to trust it less."
Samuel Johnson

INTRODUCTION

This study is an investigation of late prehistoric irrigation agriculture in North Coastal Peru. There has been much debate over the significance of irrigated agriculture to the development of indigenous civilization on the North Coast of Peru. Yet, in spite of the many references to prehistoric North Coast irrigation, only recently is information regarding the technology and functioning of the prehistoric systems becoming available. Little, however, is yet known about the extent of the prehistoric irrigation systems preserved on the North Coast. It is the intent of this study to present a summary of our present knowledge regarding these aspects of North Coast irrigation agriculture, to suggest methods and avenues for continued research, and to propose several specific hypotheses with regard to late prehistoric agricultural technology and environmental exploitation.

Hypotheses

Several hypotheses regarding the technology, functioning, and extent of late prehistoric irrigated agriculture on the North Coast and in the Chicama Valley are dealt with in this study. A brief summary of the major hypotheses is presented below.

A thorough understanding of the basic hydraulic principles of open channel flow and a sophisticated surveying technology of sufficient accuracy to determine a contour of constant slope are demonstrated in the construction of the large prehispanic Peruvian irrigation systems.

In spite of the highly developed hydraulic and construction technology of the late prehistoric period, the available methods were not adequate to construct impoundment reservoirs for the storage and redistribution of irrigation water.

The primary food plants of the Late Intermediate Period were field crops such as maize, beans, yuca (manioc), and squash, with a secondary reliance on fruits.

The extensive fields in the Pampa de Mocán represent a high level agricultural project executed by the Chimu State for the cultivation of cotton and/or drought resistant maize.

The prehistoric inhabitants of the North Coast possessed a sophisticated knowledge of environmental factors and developed agricultural techniques to exploit the varied environments found within the lower coastal valleys.

During the prehistoric period, more land was cultivated in the lower Chicama Valley than is presently exploited by modern agriculture.

By the late prehistoric period, agricultural exploitation was beginning to press the environmental limits of the lower Chicama Valley.

Temporal Parameters

Irrigation agriculture has a long history on the North Coast of Peru, beginning possibly as early as the early Early Intermediate (Willey 1953). By the Late Intermediate (see Table 1), a highly sophisticated irrigation technology was developed. It is this period with which I am concerned in this study.

Table 1 is a compilation of the local chronologies developed for the individual valleys of the North Coast stretching from the Casma Valley in the south to the Tumbes Valley in the north. These chronologies have been drawn to scale and can be readily compared on the basis of either an absolute time scale or to the relative chronological periods as developed by Rowe (1962) and Willey (1971)

on the far left of the chart. Two sites from the near North Highlands which had several radiocarbon dates were also included for comparative purposes. In addition to the local chronologies, selected archaeological sites from each valley have been included in their appropriate temporal position. The temporal placements of these sites are based on dendro-chronologically corrected radiocarbon dates where possible and/or on the basis of archaeological evidence where absolute dates are not available (see Tables 1 and 2). As can be seen from Table 1, there is considerable variation in the temporal placement of chronological periods on the North Coast. Table 2 presents a summary of the radiocarbon and archaeological evidence used in the temporal placement of these sites, as well as the sources from which the evidence was derived.

A brief discussion of the local chronologies presented in Table 1 is presented below. The chronology used for the La Pampa site of the near North Highlands is based on the periods defined by Terada (1979) and their associated radiocarbon dates (see Table 2). Terado (1979) feels that the placement of the Yesopampa, La Pampa, and Caserones periods is relatively correct on the basis of ceramic associations and radiocarbon dates. He is not, however, satisfied with the temporal placement of the Tornapampa Period. He feels that the association of white-on-red ceramics with a radiocarbon date of 640 ± 50 (A.D. 1295, corrected) is not likely. An early Early Intermediate date seems to him to be more reasonable. This does not appear to be unlikely if the Tornapampa white-on-red ceramics are

similar to those recovered by Smith (1978) at the relatively nearby site of Pashash. The Tornapampa Period then, as it is presented in Table 1, represents only an approximation. It seems likely that as research in the La Pampa area continues, the length of the Tornapampa Period, as presented here, will be substantially reduced and/or subdivided.

Smith (1978) presents a partial chronology which is primarily concerned with the Early Intermediate Period of the Pashash area. He has subdivided this period into four phases: the white-on-red Proto Recuay, the Early Recuay which was not recovered from the site of Pashash, the Classic Recuay, and the Post Recuay. The temporal placement of the Classic Recuay is largely based on radiocarbon dates (see Table 2), while the remaining phases are placed according to broader regional associations.

The chronology used for the Casma, Nepeña, Santa, Chao, and Saña Valleys was developed by Schaedel (personal communication) in conjunction with a settlement pattern survey he conducted from 1952 to 1955. This chronology is primarily concerned with the post Early Intermediate occupation of the North Coast. It consists of five lettered periods, based on ceramic and architectural evidence, ranging in length from 50 to 250 years. Many of the sites shown on Table 1 were placed on the basis of archaeological evidence collected by Schaedel during this survey.

Recent investigations by West (1977, n.d., personal communication) in the Viru Valley have modified the temporal placement of

some of the chronological periods defined during the Viru Valley Project (Ford 1949; Willey 1953). On the basis of radiocarbon dates, West has determined that the Gallinazo and Puerto Moorin Periods are somewhat later than had initially been supposed (see Table 2). This may have an important impact on the placement of periods along much of the North Coast. Ceramic styles presumed to be related to Gallinazo and Puerto Moorin are often placed with reference to the Viru Valley sequence. The radiocarbon dates collected by West represent the only available dates for this time period on the North Coast.

On the basis of data collected during the Chan Chan, Moche Valley Project, Donnan and Mackey (1978) have developed a chronology for the Moche Valley. Two important differences are readily apparent when it is compared to others proposed for North Coastal valleys. The first relates to the presence of the Middle Horizon. Donnan and Mackey are of the opinion that there is no evidence for a Wari or Middle Horizon incursion, or even substantial Wari influence in the Moche Valley. Rather, they see a continuous progression from Moche into Chimu, preferring to subdivide the Chimu into Early, Middle, and Late periods. The Early Chimu Period roughly corresponds to what has traditionally been considered the Middle Horizon on the North Coast. A discussion of the various arguments concerning the validity of the Middle Horizon on the North Coast is far beyond the scope of this presentation. However, such a work is presently being compiled by Schaedel and Vreeland (personal communication).

The second important difference is the temporal placement of the Gallinazo and Salinar periods. The later corresponds to the Puerto Moorin in the Viru Valley. The complete lack of available radiocarbon dates for these periods in the Moche Valley suggests that they were placed on the basis of the earlier Viru Valley sequence. West's revision of the temporal placement of these periods in the Viru Valley would seem to require a similar adjustment in the Moche Valley. In order to facilitate comparisons on the basis of an absolute time scale, Cerro Arena, a Salinar Period site in the Moche Valley for which there are no available radiocarbon dates, has been placed so as to correspond with the dated Puerto Moorin Period in the Viru Valley.

Rodriguez Suy Suy (n.d.) has slightly modified the chronology developed by Schaedel (personal communication) for use in the Chicama Valley. These modifications consist of the addition of descriptive names for several of the periods, but more importantly he has included period designations prior to the Middle Horizon. Rodriguez Suy Suy has used the same names as those used by Rowe (1962) and Willey (1971), but does not use the same temporal placement. The Pre-ceramic, he defines as extending until 1500 B.C., with the Initial Horizon extending from 1500 B.C. to 900 B.C. The Early Horizon (Chavinoid) begins in the Chicama Valley about 900 B.C. and extends until A.D. 200. In order to extend the Early Horizon this late, Rodriguez Suy Suy has apparently included the Salinar Period in the Chicama Valley as a part of the Early Horizon rather than as

part of the Early Intermediate, as is more often the case. As a result, he defines the Early Intermediate Period as having lasted from A.D. 200 until about A.D. 750, the earliest occurrence of the Middle Horizon on the North Coast, as defined by Schaedel.

Ubbelohde Doering's excavations of burials at the site of Pacatnamu in the Jequetepeque Valley served as the basis for the ceramic sequence presented by Hecker and Hecker (1977). This sequence, unfortunately, was not tied to an absolute time scale. It was, therefore, necessary to make temporal placements on the basis of stylistic similarities with other more firmly placed materials, a risky exercise at best and a highly misleading and self-fulfilling one at worst. The three ceramic types enclosed in brackets (see Table 1) are not clearly differentiated as to their relationships to other types in the valley, but appear to be in reverse order. All three of these types, however, seem to fit in the early Middle Horizon, Schaedel's A and B periods.

Zevallos Quinones (1971) has developed a chronology for the Lambayeque Valley which I have also applied, in somewhat modified form, to the Leche and Motupe Valleys, given their close proximity and documented prehistoric relationships (Kosok 1959a). In light of recent investigations at Pampa Grande from which radiocarbon samples associated with Moche V materials were dated to between A.D. 600 and A.D. 700 (see Talbe 2), I have modified the presented chronology by shifting the Mochicoid (Sierra Influence) to coincide with this time period. Zevallos Quinones had included this type and the "Cachacos"

(Lambayeque I Transitional) in the Middle Horizon. A proportional adjustment of these and the later types indicates that the Mochicoid and "Cachacos" types might more appropriately be included in the late Early Intermediate, and that the "Caballito" Series (cream-on-red - red-on-cream) and Tricolor styles fall within the Middle Horizon. Schaedel (personal communication) indicates that such an adjustment is more consistent with ceramic associations from the other North Coast valleys and his own investigations in the Lambayeque Valley. The choice of the term Cajamarca for the period immediately preceding the Chimu is unfortunate as it is easily confused with the earlier polychrome Cajamarca style. Similarities suggest that Cajamarca Derived might be more appropriate.

Matos (1965-66) has described a ceramic series which was recovered from the surface collection of sites in the Piura Valley. As in the Jequetepeque, it was necessary to relate the described types to similar materials which are more firmly placed in time in order to produce a comparable sequence. In this article, Matos' (1965-66) primary concern is with the definition, chronological relationships, and placement of the Vicus style. He determined, on the basis of ceramic associations, that the Vicus style fit somewhere between the end of the Cupisnique and the beginning of the Middle Horizon (Mochica/Huari), with the most likely period being between the Garbanzal and early Moche periods.

Subsequent investigations by Disselhoff (1971), during which radiocarbon samples were collected and dated, indicate that Vicus

probably dates from about A.D. 300 to A.D. 600 or 700. A re-examination of the ceramic evidence presented by Matos (1965-66) indicates that the Moche periods 2-4 which roughly correspond to this time period are rare or absent. This might suggest that the Vicus style was most strongly influenced by Moche 1, or vice-versa, but became more isolated during Moche periods 2 through 4 when it became a distinctive regional style. During the later Vicus, Moche ceramics are again recovered, suggesting that contacts with the Moche peoples were revived, possibly due to a northward movement instigated by pressures from Middle Horizon (Wari?) peoples from the south.

On the basis of excavations conducted at the Garbanzal and Pechiche sites in the Tumbes Valley, Izumi and Terada (1966) described four chronological periods. While radiocarbon samples were collected and dated, these periods are not well defined. The beginning and end of each period is based on descriptions of related types given by the authors and on the available radiocarbon dates. In one case, four radiocarbon samples associated with Garbanzal ceramics dated from about A.D. 1050 to A.D. 1160 (see Table 2). Izumi and Terada (1966), however, feel that in spite of their internal consistency, these dates are too late and would prefer to place the Garbanzal Period between about 500 B.C. and A.D. 500.

The inconsistencies and discrepancies found in the numerous chronologies of the North Coast valleys point to two major deficiencies in the archaeological investigations which have been

conducted on the North Coast. The first, as noted by Shimada (n.d.), is that many of the investigations conducted on the North Coast have concentrated on only a single valley. Multi-valley studies designed to elucidate continuities and differences between valleys are almost non-existant. As a result, there has been a confusing proliferation of local chronologies and ceramic styles which are not readily related to those of even adjacent valleys. Comparisons to more distant valleys is even more difficult and increasingly tenuous.

The lack of absolute dates for the defined chronological periods is a major impediment to intervalley studies. Investigations for the most part have been restricted to only a few chronological periods in each valley with the result that ^{14}C dates tend to be highly clustered in most valleys and entirely lacking in others. Chronologies on the North Coast have, for this reason, been largely intuitive with regard to the length and exact temporal placement of the defined periods. This situation will, of course, be remedied as more dates are run and research on the less well studied periods and valleys is undertaken.

The time period of primary concern in this study is roughly equivalent to the Late Intermediate Period, as defined by Rowe (1962) and Willey (1971). As I have described above, the proliferation of local chronologies has tended to obscure intervalley continuities.

During this period, the North Coast was dominated by the Chimu Empire. At its maximum extent, immediately prior to the Inca

Table 2. Radiocarbon and archaeological evidence used for the chronological placement of sites on Table 1.

VALLEY	SITE	RADIOCARBON EVIDENCE			ARCHAEOLOGICAL EVIDENCE			COMMENTS
		SAMPLE #	AGE[1]	REFERENCES	CERAMICS	ARCHITECTURE	REFERENCES	
Near North Highlands	Pashash	Tx-1331	1100 ± 270 (1083 ± 275) (AD 876)	(Valastro, Davis, and Varela 1975)	X	X	(Smith 1978)	Date too late to date associated ceramics (Smith 1978)
		Tx-943	1380 ± 100 (1358 ± 102) (AD 592)	(Valastro, Davis, and Varela 1975)				
		Tx-1329	1400 ± 60 (1379 ± 64) (AD 571)	(Valastro, Davis, and Varela 1975)				See Tx-1824.
		Tx-1330	420 ± 80 (456 ± 89) (AD 494)	(Valastro, Davis, and Varela 1975)				
		Tx-941	1490 ± 70 (1471 ± 73) (AD 479)	(Valastro, Davis, and Varela 1975)				
		Tx-940	1500 ± 90 (1481 ± 93) (AD 469)	(Valastro, Davis, and Varela 1975)				
		Tx-942	1580 ± 70 (1563 ± 75) (AD 387)	(Valastro, Davis, and Varela 1975)				
		Tx-1824	1590 ± 60 (1574 ± 66) (AD 376)	(Valastro, Davis, and Varela 1977)				This sample was expected to date the same as Tx-1329 This early date suggests that it was not in primary context when it was collected, see (Valastro, Davis, and Varela 1977)
		Tx-1332	1610 ± 170 (1595 ± 172) (AD 355)	(Valastro, Davis, and Varela 1975)				
		Tx-944	1640 ± 80 (1627 ± 84) (AD 323)	(Valastro, Davis, and Varela 1975)				
	La Pampa	Tk-193	500 ± 70 (529 ± 80) (AD 1421)	(Terada 1979)	X	X	(Terada 1979)	Caserones Period - Inca.
		Tk- 173	640 ± 50 (655 ± 58) (AD 1295)	(Terada 1979)				Tornapampa Period - ? Terada feels that this date is too late to date the associated ceramics (White on Red).
		Tk-195	2490 ± 60 (2601 ± 121) (651 BC)	(Terada 1979)				La Pampa Period - Chavin.

Table 2. continued.

VALLEY	SITE	RADIOCARBON EVIDENCE			ARCHAEOLOGICAL EVIDENCE			COMMENTS
		SAMPLE #	AGE[1]	REFERENCES	CERAMICS	ARCHITECTURE	REFERENCES	
	La Pampa (continued)	Tk-176	2620 ± 70 (2763 ± 86) (813 BC)	(Terada 1979)				La Pampa Period - Chavin.
		Tk-175	2920 ± 70 (3143 ± 76) (1193 BC)	(Terada 1979)				Yesopampa Period - pre-Chavin.
		Tk-174	3090 ± 70 (3363 ± 89) (1413 BC)	(Terada 1979)				Yesopampa Period - pre-Chavin.
		Tk-192	3100 ± 70 (3375 ± 89) (1425 BC)	(Terada 1979)				Yesopampa Period - pre-Chavin.
		Tk-187	3120 ± 110 (3401 ± 123) (1451 BC)	(Terada 1979)				Yesopampa Period - pre-Chavin.
		Tk-186	3350 ± 100 (3701 ± 109) (1751 BC)	(Terada 1979)				Yesopampa Period - pre-Chavin.
Casma	Huaca Moxeque	---				X	(Schaedel p.c.)	
	Pampa Llama	---			X	X	(Schaedel p.c.)	
	Pueblo de Moxeque	---			X	X	(Schaedel p.c.)	
	Manchan	---			X	X	(Schaedel p.c.)	
	Pampa Adentro	---			X	X	(Schaedel p.c.)	
	Cerro Sechin	Tk-105	1100 ± 70 (1083 ± 87) (AD 867)	(Matsuzawa 1978)	X	X	(Matsuzawa 1978)	
		Tk-106	2720 ± 60 (2887 ± 78) (937 BC)	(Matsuzawa 1978)				
		Tk-107	2940 ± 120 (3168 ± 124) (1218 BC)	(Matsuzawa 1978)				
	Las Haldas	Tk-121	2360 ± 90 (2379 ± 138) (429 BC)	(Matsuzawa 1978)	X	X	(Matsuzawa 1978)	Due to the spatial proximity and homogeneity of the formation from which this sample and sample Gak-106 were collected a much closer correspondence of dates was expected, see (Matsuzawa 1978).
		V-901	2492 ± 100 (2604 ± 145) (654 BC)	(Engel 1964)				

Table 2. continued.

VALLEY	SITE	RADIOCARBON EVIDENCE			ARCHAEOLOGICAL EVIDENCE			COMMENTS
		SAMPLE #	AGE①	REFERENCES	CERAMICS	ARCHITECTURE	REFERENCES	
	Las Haldas (continued)	NZ-211	2500 ± 100 (2613 ± 145) (663 BC)	(Fergusson and Rafter 1959)				
		NZ-370-1	2500 ± 100 (2613 ± 145) (663 BC)	(Engel 1966)				
		Tk-122	2520 ± 60 (2638 ± 121) (688 BC)	(Matsuzawa 1978)				See Gak-107.
		Tk-123	2590 ± 80 (2725 ± 94) (775 BC)	(Matsuzawa 1978)				On the basis of stratigraphic relationships and ceramic associations Matsuzawa (1978:667) concluded that: "A difference of 560 years between F/3 (sample Gak-4455) and BEX/9 (sample Tk-123) is well over our expectations."
		Gak-106	2690 ± 150 (2837 ± 158) (887 BC)	(Ishida et al. 1960)				② See Tk-121.
		Gak-4455	3150 ± 90 (3440 ± 105 (1490 BC)	(Matsuzawa 1978)				See Tk-123.
		Gak-107	3590 ± 130 (4003 ± 198) (2053 BC)	(Ishida et al. 1960)				② Matsuzawa notes that there is a major discrepency between this date and Tk-122 both of which were collected from "what appeared to be a homogenous matrix." The stratigraphic evidence does not support such an early date. See (Matsuzawa 1978).
		Gak-4456	3600 ± 95 (4030 ± 161 (2080 BC)	(Matsuzawa 1978)				
		V-902	3792 ± 80 (4268 ± 123) (2318 BC)	(Engel 1963)				
		NZ-370-2	3800 ± 80 (4291 ± 123) (2341 BC)	(Engel 1966)				

Table 2. continued.

VALLEY	SITE	RADIOCARBON EVIDENCE			ARCHAEOLOGICAL EVIDENCE			COMMENTS
		SAMPLE #	AGE①	REFERENCES	CERAMICS	ARCHITECTURE	REFERENCES	
	Chancayillo	L-404a	2300 ± 80 (2372 ± 132) (422 BC)	(Olsen and Broecker 1959)	X	X	(Fung and Gurmendi 1973; Schaedel p.c.)	This date appears to be too early to date the primary occupation of this site and may represent the reuse of material from nearby stylistically older sites. (Schaedel p.c.)
Nepena	Panamarca	---			X	X	(Schaedel p.c.)	
	Punkuri - Alto	---			X	X	(Schaedel p.c.)	
	Huambacho Viejo	---			X	X	(Schaedel p.c.)	
	Huaca Partida	---			X	X	(Schaedel p.c.)	
	Agua Hediondo	---			X	X	(Schaedel p.c.)	
	Huacatambo	---			X	X	(Schaedel p.c.)	
Santa	Inca Pampa	---			X	X	(Schaedel p.c.)	
	Tanque	---			X	X	(Schaedel p.c.)	
	Huacas de Chimbote	---			X	X	(Schaedel p.c.)	
	Choloque	---			X	X	(Schaedel p.c.)	
	Entres Cerros	---			X	X	(Schaedel p.c.)	
	El Huabo	---			X	X	(Schaedel p.c.)	
	Alto Peru	---			X	X	(Schaedel p.c.)	
Chao	Las Salinas	---						Perceramic site investigated by Walter Alva.
Viru	Castillo de Tomoval	---			X	X	(Strong and Evans 1952)	
	Huaca de la Cruz	C-619	1837 ± 190 (1939 ± 193) (AD 111)	(Libby 1951)	X	X	(Strong and Evans 1952)	③ This date seems to be too early on the basis of recent dates on materials with similar ceramic and stylistic associatiions, see L335a.
		L335a	1300 ± 80 (1278 ± 95) (AD 678)	(Broecker and Kulp 1957)				③ This date is more consistent with recent dates on materials with similar assocations.
		L-335b	1300 ± 80 (1278 ± 95) (AD 678)	(Broecker and Kulp 1957)				See L-335a.

Table 2. continued.

VALLEY	SITE	RADIOCARBON EVIDENCE			ARCHAEOLOGICAL EVIDENCE			COMMENTS
		SAMPLE #	AGE①	REFERENCES	CERAMICS	ARCHITECTURE	REFERENCES	
	Gallinazo	---			X	X	(Strong and Evans 1952)	
	V-66	UCLA ? (1975B)	1600 ± 60 (1584 ± 66) (AD 366)	(West p.c.)	X	X	(Strong and Evans 1952)	④ Late Gallinazo Period? (West p.c.)
		UCLA-? (1975A)	2035 ± 60 (2062 ± 70) (112 BC)	(West p.c.)				④ Puerto Moorin Period (West p.c.).
	Guanape	---			X	X	(Strong and Evans 1952)	
	V-434	UCLA-? (1974D)	1600 ± 60 (1584 ± 66) (AD 366)	(West p.c.)	X	X	(West p.c.)	④ Gallinazo Period (West p.c.).
		UCLA-? (1974A)	1870 ± 70 (1876 ± 79) (AD 74)	(West p.c.)				④ Late Puerto Moorin/Early Gallinazo (West p.c.).
		UCLA-? (1974C)	1890 ± 70 (1899 ± 79) (AD 51)	(West p.c.)				④ Puerto Moorin Period (West p.c.).
		UCLA-? (1974B)	1950 ± 60 (1965 ± 70) (15 BC)	(West p.c.)				④ Puerto Moorin Period (West p.c.).
		UCLA-? (1974E)	2260 ± 70 (2324 ± 119) (374 BC)	(West p.c.)				④ Late Early Horizon? (Cupisnique) (West p.c.).
Moche	Caballo Muerto	Tx-2181	1560 ± 120 (1543 ± 123) (AD 407)	(T. Pozorski 1976)	X	X	(T. Pozorski 1976)	Pozorski states that this sample was collected from possibly disturbed context and doesn't date the structure intended, see (T. Pozorski 1976: 113).
		Tx-1939	2390 ± 70 (2480 ± 126) (530 BC)	(T. Pozorski 1976)				This site is a Coastal Chavin ceremonial center.
		Tx-2180	2800 ± 60 (2969 ± 67) (1019 BC)	(T. Pozorski 1976)				
		Tx-1937	3040 ± 60 (3297 ± 81) (1347 BC)	(T. Pozorski 1976)				
		Tx-1973	3140 ± 60 (3427 ± 81) (1477 BC)	(T. Pozorski 1976)				
		Tx-1972	3310 ± 80 (3649 ± 91) (1699 BC)	(T. Pozorski 1976)				

Table 2. continued.

VALLEY	SITE	RADIOCARBON EVIDENCE			ARCHAEOLOGICAL EVIDENCE			COMMENTS
		SAMPLE #	AGE①	REFERENCES	CERAMICS	ARCHITECTURE	REFERENCES	
	Caballo Muerto (continued)	Tx-1938	3450 ± 70 (3832 ± 82) (1882 BC)	(T. Pozorski 1976)				
		Tx-1974	3680 ± 80 (4134 ± 153) (2184 BC)	(T. Pozorski 1976)				Pozorski (1976) is of the opinion that this date is a little too early.
	Galindo	?	(AD 570 - 590) (AD 650 - 670)	(Shimada n.d.) (Shimada n.d.)	X	X	(Schaedel p.c.)	⑤ This site as defined here covers a large area extending about 6 kilometers from Caballo Muerto to Quebrada Katuay.
	Moche Huacas	C-382	2823 ± 500 (3013 ± 501) (1063 BC)	(Bird 1951)	X	X	(Schaedel p.c.)	③ This date is far to early to date the Moche I ceramics with which it was associated.
	Gramalote	Tx-1930A	3050 ± 110 (3310 ± 123) (1360 BC)	(S. Pozorski 1976)	X	X	(S. Pozorski 1976)	Coastal habitation site contemporary with Caballo Muerto
		Tx-1929A	3070 ± 90 (3337 ± 106) (1387 BC)	(S. Pozorski 1976)				
		Tx-1929B	3250 ± 120 (3570 ± 124) (1620 BC)	(S. Pozorski 1976)				
		Tx-1931B	3280 ± 60 (3610 ± 74) (1660 BC)	(S. Pozorski 1976)				
		Tx-1931A	3530 ± 60 (3912 ± 137) (1962 BC)	(S. Pozorski 1976)				
		Tx-1930B	3540 ± 80 (3951 ± 91) (2001 BC)	(S. Pozorski 1976)				
	Cerro Arena	---			X	X	(Brennan 1978)	
	Huaca Dragon	---			X	X	(Schaedel 1966)	
	Chan Chan	Gx-3253	730 ± 150 (718 ± 153) (AD 1232)	(Moseley 1975)	X	X	(Moseley 1975)	Uhle Compound
	Alto Salaverry	---					(S. Pozorski 1976)	This is a preceramic site investigated by S. Pozorski (1976).

Table 2. continued.

VALLEY	SITE	RADIOCARBON EVIDENCE			ARCHAEOLOGICAL EVIDENCE			COMMENTS
		SAMPLE #	AGE①	REFERENCES	CERAMICS	ARCHITECTURE	REFERENCES	
	Padre Aban	Tx-1935	3670 ± 260 (4122 ± 291) (2172 BC)	(Valastro, Davis, and Varela 1978)			(S. Pozorski 1976)	Preceramic site investigated by the Pozorskis, T. Pozorski is of the opinion that this date may be too late, see (Valastro, Davis, and Varela 1978).
		Tx-1933	3850 ± 210 (4356 ± 230) (2406 BC)	(Valastro, Davis, and Varela 1978)				Tx-1933 and Tx-1934 are consistent with evidence that site is preceramic and lacks textiles.
		Tx-1934	3930 ± 120 (4461 ± 152) (2511 BC)	(Valastro, Davis, and Varela 1978)				
		Tx-1936	5420 ± 140 (6242 ± 189) (4292 BC)	(Valastro, Davis, and Varela 1978)				T. Pozorski is of the opinion that: "Tx-1936 is much too old."
	Choroval	---			X		(S. Pozorski 1976)	
	Cerro la Virgen	---			X	X	(Keatinge 1975)	
Chicama	Quebrada de Oso	UCLA-1711I	780 ± 110 (783 ± 114) (AD 1167)	(Kus 1972)	X	X	(Keatinge and Day 1973)	Sample from adjacent Intervalley Canal.
	Jaguay	---			X	X	(personal reconniassance)	
	La Laguna	---			X	X	(Kosok n.d.; personal reconniassance)	
	Pampas de Jaguay	---			X	X	(Schaedel p.c.)	
	Huaca Puckuche	---				X	(Larco Hoyle 1941)	
	Pelenque	---			X		(Donnan 1968;personal reconniassance)	This site extends to the east of Hda. Sausal along the base and sides of the cerros to quebrada Pelenque.
	Mocollope	---			X	X	(Schaedel p.c.)	
	Pampa Chiquitoy Viejo	---			X	X	(Conrad 1977; Eling p.c.; Schaedel p.c.)	
	Huaca Prieta	C-318	1989 ± 196 (1982 ± 199) (32 BC)	(Arnold and Libby 1951; Bird 1951)	X	X	(Bird 1948)	③ Bird believes this sample was very likely contaminated and as a result dated far too late, such a late date is not supported by stratigraphic evidence, see (Bird 1951).

Table 2. continued.

VALLEY	SITE	RADIOCARBON EVIDENCE			ARCHAEOLOGICAL EVIDENCE			COMMENTS
		SAMPLE #	AGE①	REFERENCES	CERAMICS	ARCHITECTURE	REFERENCES	
	Huaca Prieta (continued)	C-323	2631 ± 300 (2779 ± 304) (829 BC)	(Libby 1951)				③ This date appears to be too early to date the associated Gallinazo ceramics when compared to dates on similarly associated samples from the Viru Valley, see V-434, UCLA-? (1974A).
		C-75	2665 ± 200 (2819 ± 206) (869 BC)	(Arnold and Libby 1951)				③ Associated with maize and Cupisnique ceramics, see (Bird 1951).
		C-321	2966 ± 300 (3201 ± 301) (1251 BC)	(Arnold and Libby 1951)				③ This sample is stratigraphically earlier than C-322, large standard deviations however may account for the apparent discrepency. Bird (1951) also notes that C-322 (a digging stick) may have been old when it was discarded. Terminal preceramic? (Bird 1951).
		C-322	3278 ± 250 (3607 ± 254) (1657 BC)	(Arnold and Libby 1951)				③ This sample was assayed twice. See C-321.
			3333 ± 340 (3680 ± 343) (1730 BC)	(Bird 1951)				
		C-318b	3550 ± 600 (3963 ± 614) (2013 BC)	(Arnold and Libby 1951)				③ This is a rerun on sample C-318a and is far more consistent with archaeological and stratigraphic evidence, see (Bird 1951).
		C-315	3572 ± 220 (3992 ± 255) (2042 BC)	(Arnold and Libby 1951)				③ This sample is from the same stratigraphic unit as C-316. Neither of these dates is entirely consistent with the stratigraphic evidence, see (Bird 1951).

Table 2. continued.

VALLEY	SITE	RADIOCARBON EVIDENCE			ARCHAEOLOGICAL EVIDENCE			COMMENTS
		SAMPLE #	AGE①	REFERENCES	CERAMICS	ARCHITECTURE	REFERENCES	
	Huaca Prieta (continued)	L-116B (1)	3650 ± 400 (4096 ± 421) (2146 BC)	(Kulp, Feely, and Tryon 1951)				③ This sample was the same material used in C-598.
		L-116A	3780 ± 100 (4265 ± 137) (2315 BC)	(Broecker, Kulp, and Tucek 1956)				The same material used in samples C-598 and L-116B (1) was dated twice more by the Lamont Laboratory using an improved CO^2 method. These two dates should therefore more accurately reflect the true age of this material than samples C-598 or L-116B (1). These dates are consistent with the beginning of the Cotton Preceramic.
		L-116B (2)	3860 ± 100 (4363 ± 137) (2413 BC)	(Broecker, Kulp, and Tucek 1956)				
		C-362	4043 ± 300 (4606 ± 317) (2656 BC)	(Libby 1951)				③
		C-313	4257 ± 250 (4880 ± 276) (2930 BC)	(Arnold and Libby 1951)				③ "On the basis of stratigraphy sample 313 is older that 316," (Bird 1951:37). Given the large standard deviations however these dates are not unreasonable.
		C-598	4298 ± 230 (4931 ± 294) (2981 BC)	(Libby 1951)				③ See L-116B (1), and L-116A.
		C-316	4380 ± 270 (5034 ± 285) (3084 BC)	(Arnold and Libby 1951)				③ See sample C-313.
Jequetepeque	Cerros Kanchape	---			X	X	(Eling p.c.)	
	Moro	---			X	X	(Schaedel p.c.; Eling p.c.)	
	Cañoncillo	---			X	X	(Schaedel p.c.; Eling p.c.)	
	Pacatnamu	Hv-?	(AD 485)	(Ubbelohde Doering 1967)	X	X	(Ubbelohde Doering 1967)	⑥ Average age of samples reported by Ubbelohde Doering (1967:22).

Table 2. continued.

VALLEY	SITE	RADIOCARBON EVIDENCE			ARCHAEOLOGICAL EVIDENCE			COMMENTS
		SAMPLE #	AGE[1]	REFERENCES	CERAMICS	ARCHITECTURE	REFERENCES	
	Ventanillas	---			X	X	(Schaedel p.c.; Eling p.c.)	
	Talambo	---			X	X	(Schaedel p.c.; Eling p.c.)	
	Farfan	---			X	X	(Schaedel p.c.; Eling p.c.)	
	Monte Grande-Tembladera	---			X	X	(Schaedel p.c.; Eling p.c.)	
	Templete Chavin	---			X	X	(Eling p.c.)	
Saña	Huaca Teodora	---			X	X	(Schaedel p.c.)	
	Huaca Quiñones	---			X	X	(Schaedel p.c.)	
	Cerro Guitarres	---			X	X	(Schaedel p.c.)	
	Otra Banda	---			X	X	(Schaedel p.c.)	
	Cerro Corbacho	---			X	X	(Schaedel p.c.)	
Lambayeque	Pampa de los Burros	---			X	X	(Schaedel p.c.)	
	Patapo	---			X	X	(Schaedel p.c.)	
	Pampa Grande	A-1704	1280 ± 70 (1258 ± 76) (AD 692)	(Shimada n.d.)	X	X	(Shimada n.d.; Schaedel p.c.)	Moche V associations.
		SMU-399	1300 ± 60 (1278 ± 79) (AD 672)	(Shimada n.d.)				Moche V associations.
		A-1705	1380 ± 70 (1358 ± 82) (AD 592)	(Shimada n.d.)				Moche V associations.
	Sipan	---			X	X	(Schaedel p.c.)	
	Colluz	---			X	X	(Schaedel p.c.)	
	Chotuna	Bonn-1958	590 ± 70 (588 ± 80) (AD 1362)	(Scharpenseel and Pietig 1974)				
		Bonn-1957	720 ± 70 (728 ± 76) (AD 1222)	(Scharpenseel and Pietig 1974)				
Leche	Batan Grande	GrN-5474	915 ± 50 (909 ± 59) (AD 1041)	(Vogel and Lerman 1969)	X	X	(Shimada n.d.; Schaedel p.c.)	
	Purgatorio	---			X	X	(Schaedel p.c.)	
	Mirador	Bonn-1141	660 ± 60 (674 ± 67) (AD 1276)	(Trimborn 1972)	X	X	(Schaedel p.c.)	

Table 2. continued.

VALLEY	SITE	RADIOCARBON EVIDENCE			ARCHAEOLOGICAL EVIDENCE			COMMENTS
		SAMPLE #	AGE[1]	REFERENCES	CERAMICS	ARCHITECTURE	REFERENCES	
	Mirador (continued)	Bonn-1142	680 ± 50 (692 ± 58) (AD 1258)	(Trimborn 1972)				
	Tambo Real	---			X	X	(Schaedel p.c.)	
	Banderas	---			X	X	(Schaedel p.c.)	
Motupe	Jotoro	---			X	X	(Schaedel p.c.)	
	La Viña	---			X	X	(Schaedel p.c.)	
	Apurle	Bonn-1813	1100 ± 70 (1083 ± 87) (AD 867)	(Trimborn 1972)	X	X	(Schaedel p.c.)	
		Bonn-1145	1430 ± 50 (1409 ± 55) (AD 541)	(Trimborn 1972)				
Piura	Vicus	Hv-1519	1295 ± 100 (1273 ± 112) (AD 677)	(Disselhoff 1971)	X		(Disselhoff 1971)	
		Hv-1520	1480 ± 60 (1460 ± 64) (AD 530)	(Disselhoff 1971)				
		Hv-1521	1490 ± 70 (1471 ± 73) (AD 479)	(Disselhoff 1971)				
		Hv-1517	1525 ± 115 (1507 ± 117) (AD 443)	(Disselhoff 1971)				
		Hv-1518	1700 ± 110 (1691 ± 113) (AD 259)	(Disselhoff 1971)				
		Gx-216	2030 ± 105 (2056 ± 111) (106 BC)	(Engel 1966)				This date is based on materials not recovered from a controlled excavation and has a questionable context. It also appears to be too early when compared to the other available dates.
Tumbes	Garbanzal	N-85	3680 ± 130 (4135 ± 184) (2185 BC)	(Yamasaki, Hamada, and Fujiyama 1966)	X	X	(Izumi and Terada 1966)	
		Gak-55	1730 ± 70 (1723 ± 75) (227 BC)	(Ishida et al. 1960)				

Table 2. continued.

VALLEY	SITE	RADIOCARBON EVIDENCE			ARCHAEOLOGICAL EVIDENCE			COMMENTS
		SAMPLE #	AGE[1]	REFERENCES	CERAMICS	ARCHITECTURAL	REFERENCES	
	Garbanzal (continued)	N-84	7510 ± 260 (7735 ± 260) (5785 BC)	(Yamasaki, Hamada, and Fujiyama 1966)				This date is beyond the limits of the available dendrochronological correction tables, but was corrected to the 5730 half-life. Sample N-84 was not reported by the archaeologists probably because it's age is not consistent with it's context, it is very much too old.
	Pechiche	N-75	785 ± 120 (788 ± 124) (AD 1162)	(Yamasaki, Hamada, and Fujiyama 1966)	X	X	(Izumi and Terada 1966)	Izumi and Terada feel that this date as well as those from samples N-72, N-82, and N-83 are too late. However these dates are all internally consistent.
		N-72	810 ± 150 (811 ± 153) (AD 1139)	(Yamasaki, Hamada, and Fujiyama 1966)				See N-75.
		N-82	860 ± 110 (857 ± 114) (AD 1093)	(Yamasaki, Hamada, and Fujiyama 1966)				See N-75.
		N-83	910 ± 120 (904 ± 124) (AD 1046)	(Yamasaki, Hamada, and Fujiyama 1966)				See N-75.
		N-80	2260 ± 130 (2324 ± 324) (374 BC)	(Yamasaki, Hamada, and Fujiyama 1966)				This sample and sample Gak-? (reported as BC-35) (Izumi and Terada 1966) are not consistent with their presumed stratigraphic relationship, see (Izumi and Terada 1966).
		Gak-?	2800 ± 120 (2898 ± 130) (948 BC)	(Izumi and Terada 1966)				This date appears to have been reported using a correction for the 5730 half-life. compare (Izumi and Terada 1966) and (Yamasaki, Hamada, and Fujiyama 1966). It has been corrected accordingly.

Table 2. continued.

① Unless otherwise noted, original date reported is given first, standardized to 1950, and is followed by ages corrected to 5730 half-life and calibrated using dendrochronological correction (Damon et al. 1974). The standard deviation of the corrected value was calculated as the square root of the sum of the variances, see (Damon et al. 1974:365).

② The original date as reported was standardized to 1960. This has been accounted for in the determination of the corrected age for this sample.

③ This date was determined by the use of a solid state assay technique. Refinements in the methods of assay indicate that solid state measurements may contain substantial error.

④ Sample numbers assigned by West (p.c.). UCLA assay numbers not given.

⑤ Personal communication reported to Shimada (n.d.) by G. Conrad.

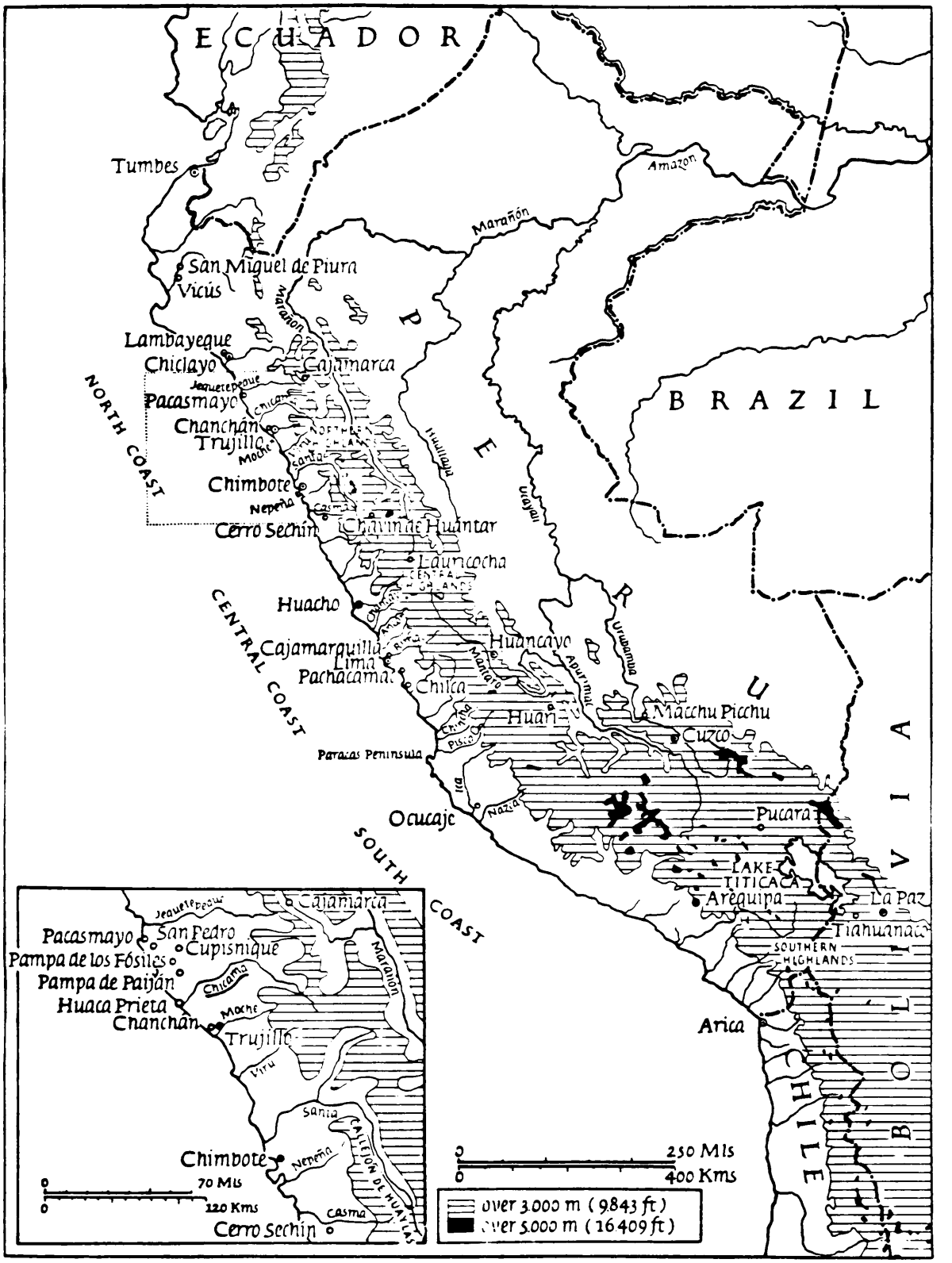
⑥ Average of three dates run by Heidelberg University. This date could not be corrected due to insufficient information.

conquest (A.D. 1476), the Chimu State controlled the coastal region of north and north-central Peru from Tumbes southward to the Rio Chillon. The eastward extent of imperial domination is somewhat more difficult to define, with evidence of Chimu influence found as far east as the Utcubamba Valley. This influence, however, was probably manifested primarily in the form of political alliances and trade with polities such as Huamachuco and Cajamarca. Actual control was probably limited to lands below approximately 2,000 meters in elevation (Lechtman 1976; Netherly 1977).

Area of Study

The areal focus of this report is the lower Chicama River Valley, located in the geographic and political center of the ancient Chimu Empire (see Maps 1 and 3). The Chicama Valley is located on the north coast of Peru between $7^{o}21'$ and $8^{o}01'$ south latitude and $78^{o}16'$ and $79^{o}27'$ west longitude. It is bordered on the north by the drainage of the Jequetepeque River, on the south by the drainages of the Moche River and the quebrada of the Seco River, on the southeast by the drainage of the Santa River, on the east by the drainage of the Marañon River, and on the west by the Pacific Ocean. The entire Chicama River drainage encompasses an area of approximately 5,822 square kilometers (ONERN 1973:I). The present study, however, is concerned with an area of only about 1041.5 square kilometers located below an elevation of 400 meters (see Appendix 1).

This area includes the coastal plain and a narrow strip of flat alluvial soil extending some 50 kilometers northeast from the



Map 1. Peru and the North Coast. Reproduced from Anton (1972:113).

mouth of the Chicama River. The coastal plain of the Chicama Valley begins approximately 44 kilometers from the coast. At this point, just east of the hacienda Sausal, the river valley begins to widen to form a roughly triangular alluvial plain. At its greatest width, this plain is approximately 45 kilometers wide. From the point where the valley begins to widen to the ocean, the river drops some 280 meters over a distance of some 44 kilometers for an average slope of 6.4%. The Chicama River flows in a southwesterly direction, closely paralleling the southern border of the alluvial plain. Consequently, there is a relatively small proportion of cultivable land on the south bank with a correspondingly large area of potentially cultivable land extending for almost 30 kilometers to the north. From the point where the valley narrows to Puente Morena, there is a narrow strip of flat alluvial soil some 15 kilometers long. These two areas constitute almost 65 percent of the land suitable for agriculture in the entire Chicama drainage and virtually all of the land suitable for large-scale irrigated agriculture (see Appendix 1).

It is within this larger area that the remains of prehistoric irrigation canals and field systems are found. They are located outside the limits of modern cultivation and suggest that extensive areas of the lower valley were intensively cultivated during the prehistoric period (Kosok 1965; Watson 1978).

The close proximity of the Chicama Valley to the Chimu capital of Chan Chan undoubtedly affected the patterns of agricultural production in the valley. The presence of the La Cumbre, or

Chicama-Moche Intervalley canal graphically illustrates the degree of control exercised over the Chicama Valley. The extensive archaeological remains of what might be termed "state fields" in the lower Chicama Valley also indicate that the agricultural patterns found there were strongly influenced by the Chimu State.

The Chicama Valley very probably served as a breadbasket for Chan Chan. As such, it would have been a vital resource of agricultural goods and may have experienced a greater level of State intervention and control than those valleys more distant from the Imperial capital.

SUMMARY OF PREVIOUS INVESTIGATIONS

Writing in 1847, Prescott describes the state of the exploration of Peruvian antiquities:

> The hand of the conquerors fell heavily on the venerable monuments of Peru; and, in their blind and superstitious search for hidden treasure, they caused infinitely more ruin than time or the earthquake. Yet enough of the monuments of the Incas remain to invite the researches of the antiquary. Those only in the most conspicuous situations have hitherto been examined. But, by the testimony of travellers, many more are to be found in the less-frequented parts of the country, and we may hope they will one day call forth a kindred spirit of enterprise to that which has so successfully explored the mysterious recesses of Central America and Yucatan (as quoted in Squire 1877:1-2).

In the past 130 years since Prescott wrote, the antiquities of Peru have continuously felt the heavy hand of its conquerors and, ironically, the increasingly heavy hand of their heirs. The ravages of the treasure seeker and the huaquero have destroyed far more than will ever be known of the civilizations and peoples of ancient Peru.

The archaeology of Peru is strongly rooted in a less than noble past. The earliest excavations carried out were undertaken by the Spanish conquerors in search of gold. During the 19th century, an actual company was formed to search for treasure at Chan Chan (Rivero and von Tschudi 1853).

The explorer/naturalists of the 19th century were, in reality, only a little better in regards to their techniques of excavation. Their appreciation of the artifacts recovered, however,

was not limited to precious metals and stones, as was the case with the earlier treasure hunters. Explorers such as M.E. Rivero and J.J. von Tschudi (1853), T. Hutchinson (1873), E.G. Squire (1877), C. Wiener (1880), and E.W. Middendorf (1893-95) provide the first systematic records of the archaeological remains of Peru. Squire also proposed that the numerous archaeological sites represented different time periods predating the Incas. Although Cieza de Leon had noted as early as 1553 that certain ruins were not of Inca style and must have predated them, this seems to have been largely ignored until Squire.

M. Uhle, a German archaeologist, first used a scientific approach to Peruvian archaeology, introducing the concept of stratigraphy and developing the first classification of pre-Incaic cultures. During the early 20th century, the work of Uhle (1914) and Hrdlicka (1911) on the North Coast illustrated an underlying concern with the origins of prehistoric cultures and peoples. This concern with origins led to an increased perception of the importance of chronological sequences. As a result of this perception, the establishment of chronologies came to dominate much of Peruvian archaeology for the next forty years. Actual work on the North Coast was largely confined to the second half of this period.

In 1930, Kroeber (1930:82-86) published the results of a brief archaeological reconnaissance and limited excavations in the Chicama Valley. Muelle (1937), published a summary of some of the archaeological resources in the Chicama Valley, but did not undertake

any new excavations or expanded reconnaissance. Bennett (1939) presented a brief discussion of limited excavations and reconnaissance at several sites in the lower valley.

The 1940's saw a flurry of activity on the North Coast centered around the Viru Valley Project sponsored by the Institute of Andean Research. In conjunction with this project, Junius Bird (1948) undertook the excavation of Huaca Prieta in the Chicama Valley. This site, which represents an early preceramic-to ceramic midden, has contributed much to our understanding of early agriculture and domestication on the coast of Peru. Unfortunately, this work has never been completely reported. James Ford, also in affiliation with the Viru Valley Project, conducted a short reconnaissance in the Chicama Valley. The results of Ford's work in the Chicama, however, have never been published.

During this period, Larco Hoyle was also conducting extensive excavations in the numerous prehistoric cemeteries located in the Chicama Valley. On the basis of this work, he established the existence of a coastal manifestation of Chavin which he called Cupisnique (Larco Hoyle 1941). In addition, he defined several other local cultures and established a chronological sequence for the North Coast (Larco Hoyle 1938-39, 1944, 1945a, 1945b, 1945c, 1946, 1948). Larco Hoyle pioneered in the study of the Mochica culture. On the basis of thousands of whole vessels which he recovered from his excavations, he was able to analyze numerous aspects of this culture (Larco Hoyle 1938-39, 1945c).

Also, during the early 1940's, Paul Kosok undertook the monumental task of recording the remains of prehistoric irrigation works in the valleys of the North Coast. In his survey of the Chicama Valley, he recorded numerous sites, as well as extensive canal systems in the lower valley. Kosok (1959b) also pioneered the study of Peruvian antiquities through the use of aerial photography. The results of this research were to have been published in two volumes. However, due to Kosok's untimely death, only the first and less technical, volume has been published (Kosok 1965).

In the 1950's and 1960's, no new research findings were published on the Chicama Valley. An unpublished Masters Thesis by James Kus (1967) contained several sections on the archaeological remains of the valley, but did not provide any new information. Kus (1972, 1974, 1978) later carried out excavations on the La Cumbre canal which are reported in his unpublished dissertation.

Heather Lechtman (1976) included a short reconnaissance of the upper Chicama Valley in her work on Peruvian metallurgy. This survey is one of only two published reports (Lechtman 1976; Watson and Kluge 1978) which include sites farther than fifty kilometers from the coast. Before this time, all of the research in the Chicama Valley was restricted to the lower valley.

In conjunction with the Chan Chan - Moche Valley Project, excavations were undertaken at the sites of Quebrada de Oso (Keatinge 1974; Keatinge and Day 1973) and Chiquitoy Viejo

(Conrad 1977) in the Chicama Valley.

At the present time, the Programa Riego Antiguo, under the auspices of the Field Museum of Natural History, is completing research in both the Moche and Chicama Valleys. No published information on the Chicama Valley is as yet available from this project.

The relative lack of published material directly concerning the Chicama Valley should not be considered as indicative of the region as a whole. The Moche and Viru Valleys, the two valleys immediately to the south of the Chicama Valley, are probably the most intensively studied areas in this region.

Fieldwork in the Chicama Valley has been restricted to the excavation of only three classes of archaeological remains and to limited systematic survey. Cemeteries compose by far the most excavated class of site in the valley (Bennett 1939; Hrdlick 1911; Kroeber 1930; Larco Hoyle 1938-39, 1944, 1945a, 1945b, 1945c, 1948; Ubbelohde-Doering 1967). Administrative/ceremonial structures (Conrad 1977; Keatinge 1974), as well as irrigation canals (Kus 1972, 1974, 1978), have also been excavated. Meanwhile, habitation areas of both elite and non-elite sectors of the population, roads and associated control structures, specialized agricultural features such as pukios and fields, and ceremonial centers have remained unexcavated.

Paul Kosok conducted probably the most systematic survey of

the lower valley to date, the results of which, as I stated earlier, are unpublished. The short surveys by Lechtman (1976) and Kluge, Rabinowitz, and Watson (1976; Watson and Kluge 1978) are the first to include the central portion of the valley. Zaki (1974, n.d.) has conducted limited survey in the upper valley. None of these surveys is adequate, however, to properly assess the archaeological resources of the valley or even to give a clear picture of the range of variability within those resources.

Given the lack of complete information, excavations have been conducted at sites which may not accurately reflect the larger archaeological record of the valley. As a result of the interests of previous investigators in the Chicama Valley, not only are certain classes of archaeological remains unrepresented in the literature but, with the possible exception of cemeteries, entire time periods are missing, as well.

In addition to the archaeological research which has focused on the North Coast, several ethnohistoric and ethnographic studies have also dealt with this region. Unfortunately, the North Coast is not blessed with the wide range of documentary resources available to many other regions of Peru. Rowe (1948) has summarized and discussed many of the known sources relevant to this region. While more recently, Rostworowski (1960), Lohmann Villena (1969-70), and Netherly (1977) have demonstrated the value of colonial litigation records for ethnohistorical research on the North Coast.

For the most part, ethnohistorical research in this region has concentrated on the reconstruction and clarification of Late Horizon and Late Intermediate Period social organization and political structures. As a result, most of the available studies are of only limited value for the purposes of this report, but have been used as supporting evidence in several cases. An important exception to this statement is the work of Yacovleff and Herrera (1934-35) on the prehispanic use and domestication of plants as recorded by the Spanish chroniclers. I have relied heavily on their work in my analysis of prehistoric cultigens on the North Coast.

Apart from the descriptions provided by a few Spanish chroniclers and some 19th century explorer/naturalists, little was recorded of the peoples of the North Coast of Peru. Ethnographic research in this region did not really begin until the second quarter of this century. The work of Jiminez-Borja (1938) was an early and less than satisfactory compilation of ethnographic description and iconographic interpretation. Larco Hoyle (1938-39) was somewhat more successful in a similar comparison, but, unfortunately, his work was never completed.

During the late 1940's and the 1950's, Gillin's (1947) monograph on the town of Moche was published, and Holmberg (1950, 1952, 1957) and Nunez del Prado (1951) conducted research in the Viru Valley. The 1960's saw little by way of new research on the

North Coast. The 1970's, however, have seen a resurgence of interest and renewed research. The work of Rodriguez Suy Suy (1975) and Sharon (1972, 1978) on traditional medicine has significant implications for our interpretation and reconstruction of prehistoric religion and beliefs. Hatch's (1976) study of traditional maize farmers in Motupe provides a useful analog for the analysis of prehistoric agricultural practices. Without a doubt, the most prolific ethnographer to work on the North Coast is Jose Sabogal Wiesse (1967, 1968, 1974, 1975, 1976, n.d.). His numerous studies have shed much light on many aspects of traditional life and culture on the North Coast of Peru.

While there are many gaps in our archaeological, ethnohistorical, and ethnographical knowledge, some approaching the Grand Canyon in scale, sufficient evidence exists to provide us with enticing glimpses of prehistoric man's adaptation to and interaction with one of the driest deserts in the world. This report is an attempt to deal with an important aspect of that adaptation - the agricultural exploitation of a desert coastal valley.

GEOLOGY AND TOPOGRAPHY

The geology and geomorphology of the coast and western slopes of the Andes are the result of a long and complicated history. The geology of the north central Andes contains igneous, metamorphic, and sedimentary rocks in complex folded and faulted relationships. The intrusive igneous rocks of this region are Cretaceous and Tertiary granites, granitic diorites, and diorites with minor inclusions of pegmatites and aplites which form part of the Andean batholith. The extrusive igneous rocks of this region are Triassic to Tertiary andesitic, rhyolitic, and dacitic flows and tuffs. Quartzites and slates compose the majority of the metamorphic rocks found in the valley. The sedementary rocks are primarily represented by Cretaceous to Quaternary conglomerates, sandstones, shales, limestones and coal (ONERN 1973).

In the lower valley, the geologic deposits of primary concern are Quaternary to Holocene in age and alluvial or eolian in nature (ONERN 1973:87-90, mapa 2). The most striking geomorphic features in this region, however, are the cerros, or hills, which jut from and border the triangular alluvial plain. Cerros, in the Chicama Valley, are erosional remnants of the Cretaceous and Tertiary igneous rock which underly the valley sediments and form the foothills of the Andes (ONERN 1973-87-90: mapa 2).

In addition to cerros, quebradas, alluvial fans, marine terraces, and eolian sand features compose the primary geomorphic features of the lower valley. Quebradas are erosional drainage

features in the form of steep sided canyons or small dry valleys on and between cerros. Alluvial fans are found wherever a quebrada opens onto the alluvial plain or the valley floor. Three marine terraces which parallel the modern shoreline are found on the North Coast. These terraces are developed on the Quaternary alluvium of the coastal region and are the result of three periods of uplift, followed by periods of standstill or negative movement which occurred during the Pleistocene (Lemon and Churcher 1961). Eolian sand deposits in the Chicama Valley are primarily restricted to areas of the northern and southern margins of the alluvial plain and to the narrow beaches.

Each of these features has played a part in man's adaptation to the arid coastal climate. Cerros have long provided places of refuge and defense (Willey 1953; Kosok 1965), and may have even played a significant role in the ceremonialism of certain coastal groups (Rabinowitz n.d.). Quebradas not only served as natural pathways and passes to areas within and between valleys, but also as major barriers to the extension of irrigation canals into regions away from the river. Quebradas, cerro sides, and alluvial fans were frequently the locations chosen for occupation areas, being above those areas which could be easily irrigated (Kosok 1965; Schaedel 1951a; Willey 1953). Several small fishing villages and numerous archaeological sites occur immediately behind the modern beach on the first marine terrace in the Chicama Valley (Kosok n.d.; Bennett 1939:84-89; Kroeber 1930:84-85). The eolian sand deposits on

the North Coast in the Chicama Valley have had their main influence in removing land from production (Kus, et al. 1977). The encroachment of aeolian deposits into agricultural areas in the Chicama Valley, however, was limited to areas along the southern edge of cultivation and to areas of excavated fields along the coast.

Man's adaptation to the North Coast has been strongly influenced by the geology and topography of the region, a fact well illustrated by the prehistoric agricultural practices found there. The igneous bedrock responsible for the abrupt topography has also served as the source material from which the fertile alluvial soils of the lower valley developed. It was these soils which supported the agricultural base necessary for the development and sustenance of state level society on the North Coast. Geologic and geomorphic influences on the distribution of subsurface water have virtually determined what regions of the lower valley were exploited through the use of excavated fields.

An understanding of the geology and topography is an integral part of the investigation of late prehistoric agriculture on the North Coast of Peru.

SOILS

Six major associations of soils have been defined in the lower Chicama Valley (ONERN 1973). Table 3 summarizes the areal extent, and indicates the equivalent soils using the USDA Soil Taxonomy (1975) for each of these associations.

Soil Association	Approximate Surface Area in Lower Valley (Hectares)	USDA Soil Taxonomy Equivalent
Eutric Fluvisols		
(irrigated)	64,700	Ustifluvents
(unirrigated)	41,200	Torrifluvents
Eutric Regosols	27,000	Torripsamments
Orthic Solonchaks	210	Salorthids
Gleyic Solonchaks	7,800	Halaquept
Eutric Regosols & Gleyic Solonchaks	800	
Desert Lithosols*		Orthent
	TOTAL = 141,710	

* Area of Desert Lithosols not included in totals. Extremely thin or total lack of soil precludes the agricultural exploitation of this association.

Table 3. Soil associations in the lower Chicama Valley, adapted from ONERN (1973:Mapa 3).

The system of soil classification adopted by the ONERN study was developed by the United Nations Food and Agricultural Organization (FAO 1974). This system was available prior to the 1974

publication, which explains the apparent discrepancy of dates with the ONERN (1973) study having been published prior to the FAO (1974) publication.

A glossary of the soils terminology used in the following descriptions can be found in Appendix 2.

Fluvisols

> Soils developed from recent alluvial deposits having no diagnostic horizons other than (unless buried by 50 cm or more new material) an orthic or an umbric A horizon, a histic H horizon, or a sulfuric horizon. As used in this definition, recent alluvial deposits are fluviatile, marine, lacustrine, or colluvial sediments characterized by one or more of the following properties:
>
> (a) having an organic matter content that decreases irregularly with depth or that remains above 0.35 percent to a depth of 125 cm (thin strata of sand may have less organic matter if the finer sediment below meets the requirements);
>
> (b) receiving fresh material at regular intervals and/or showing fine stratification;
>
> (c) having sulfidic material within 125 cm of the surface.
>
> Eutric Fluvisols
>
> Fluvisols having a base saturation (by NH_4OAc) of 50 percent or more at least between 20 and 50 cm from the surface but which are not calcareous at the same depth; lacking a sulfuric horizon and sulfidic material within 125 cm of the surface (FAO 1974:32-33).

Eutric fluvisols constitute the most agriculturally significant soils to be found in the lower Chicama Valley. Fluvisols are excellent agricultural soils when properly managed, but in some

cases, irrigation and/or drainage may be necessary to insure good permanent yields (FAO 1971:115). Irrigated eutric fluvisols presently cover some 64,700 hectares in the lower Chicama Valley and have been classified as having very good to moderate capabilities for intensive irrigated agriculture: Classes I, II, III (see Table 4). These soils are restricted to the valley floor and flat central portions of the alluvial plain.

The unirrigated eutric fluvisols cover an area of 41,200 hectares and have been classified as being moderate to useless for intensive irrigated agriculture: Classes III, IV, VIII (see Table 4).

Regosols

> Soils from unconsolidated materials, exclusive of recent alluvial deposits, having no diagnostic horizons (unless buried by 50 cm or more new material) other than an ochric A horizon; lacking hydromorphic properties within 50 cm of the surface; lacking the characteristics which are diagnostic for Vertisols and Andosols; lacking high salinity; when coarse textured, lacking lamellae of clay accumulation, features of cambic or oxic B horizons or albic material which are characteristic of Arenosols.

Eutric Regosols

> Regosols having a base saturation (by NH_4OAc) of 50 percent or more at least between 20 and 50 cm from the surface but which are not calcareous within this depth; lacking permafrost within 200 cm of the surface (FAO 1974:33).

Eutric regosols cover an area of approximately 27,000 hectares in the Chicama Valley and are wholely restricted to the lower valley. Regosols, in this area, are formed on recent Eolian

deposits and have little or no value for intensive irrigated agriculture: Classes VI, VIII (see Table 4). Regosols are limited for agricultural purposes by their low water retention and fertility (FAO 1971:119). Dunes and other topographic features also limit the utility of some regosols for irrigation agriculture.

The regosols found in the Chicama Valley are restricted to areas bordering the northern and southern limits of cultivation near the coast and to smaller areas around the bases of the larger cerros within the alluvial plain.

Solonchaks

> Soils, exclusive of those formed from recent alluvial deposits, having a high salinity and having no diagnostic horizons other than (unless buried by 50 cm or more new material) an A horizon, a histic H horizon, a cambic B horizon, a calcic or a gypsic horizon.

Orthic Solonchaks

> Solonchaks having an ochric A horizon; lacking takyric features; lacking hydromorphic properties within 50 cm of the surface (FAO 1974:35).

Orthic solonchaks cover only 210 hectares along the shoreline on the extreme southern edge of the Chicama drainage. They are classified as having no value for agricultural purposes: Class VIII (see Table 4). The primary limitation of these soils to modern cultivation is their high salinity. These soils, however, are associated with excavated fields in Northern Chile (FAO 1974:122) and may be similarly associated on the North Coast. The distribution of excavated fields within the Chicama Valley will be discussed in a later chapter.

Gleyic Solonchaks

> Solonchaks showing hydromorphic properties within 50 cm of the surface (FAO 1974:35).

Gleyic solonchaks occur only in the lower valley where they cover an area of approximately 7,800 hectares. Gleyic solonchaks are classified as having marginal or no value for intensive cultivation in the Chicama Valley: Classes IV, VIII (see Table 4). However, these soils are found, in large part, to be under cultivation (ONERN 1973:160) and to have been cultivated during the prehistoric period. The modern agricultural exploitation of these soils, though, is restricted to non-mechanized cultivation of diverse crops.

Associations of Eutric Regosols and Gleyic Solonchaks occur north and east of Puerto Chicama and encompass an area of about 800 hectares. Limited areas of these soils can be cultivated, but they are generally considered as having no value for agricultural purposes: Class VIII (see Table 4).

Desert Lithosols

> Soils which are limited in depth by continuous coherent hard rock within 10 cm of the surface (FAO 1974:34).

The lower Chicama Valley, outside of the actual alluvial plain, consists almost entirely of coherent hard rock or lithosols. Lithosols also occur on the cerros located within the alluvial plain. The extent of these soils was not determined since the lack of sufficient soil depth precludes their use for agricultural purposes. All lithosols in the Chicama Valley are classified as having no agricultural uses: Class VII (see Table 4). Areas of these soils

were used, however, for the location of prehistoric habitation and ceremonial centers.

The entire area within the lower Chicama Valley has been classified by ONERN (1973) in terms of its suitability to various types of agriculture. Eight classes were developed using four primary variables: soils, topography, drainage, and type of agriculture. The soils variable included an evaluation of such attributes as: soil depth, texture, water storage capacity, permeability, fertility and salinity. The topographic variable related specifically to the ease with which the soils could be irrigated, primarily considering the availability of water and the need for leveling of the land surface. The drainage variable is extremely important in arid regions where the combination of poor drainage and high evaporation rates tends to concentrate salts in the soil profile. This variable not only included an analysis of the soil permeability, but also the permeability of the substratum and the depth of the water table. The type of agriculture best suited to a particular soil refers primarily to the distinction between land suitable for mechanized or permanent cultivation and that only marginally or not suitable for agricultural purposes.

It is very interesting to note that a significant portion of the land within the alluvial plain which is classified as marginal (VII) or useless (VIII) is presently under cultivation. The areas of concern tend to be those dominated by the poorly drained and saline solonchak soils. Not only are significant portions of these

Type of Agriculture	Class	General Characteristics
Intensive (Mechanized)	I	Arable land very well suited for intensive agriculture and other agricultural uses.
Intensive (Mechanized)	II	Arable land well suited for intensive agriculture and other agricultural uses.
Intensive (Mechanized)	III	Arable land moderately well suited for intensive agriculture and other agricultural uses.
Intensive (Mechanized)	IV	Arable land, marginal for intensive agriculture
Permanent	V	Lands very appropriate for permanent cultivation, pasturage and forestation; generally not arable.
Permanent	VI	Lands appropriate for permanent cultivation, pasturage and forestation; not arable.
Marginal	VII	Agriculturally marginal land suitable only for extensive pasturage and forests; not arable.
Without Use	VIII	Lands not useful for agricultural purposes or forests

Table 4. Land classification of capability for agricultural use, translated from ONERN (1973:Mapa 3).

soils being cultivated at the present time, but recent evidence (Rodriguez Suy Suy, personal communication) indicates that they were also extensively exploited during the prehistoric period. Through the use of a specialized system of ridged fields and drainage and through the use of cultigens tolerant to saline conditions, the prehistoric population, and recently the modern peasant farmers, were able to efficiently exploit a region presently classified as useless. Denevan (1970:654, footnote #46) found a similar situation in the regions bordering Lake Titicaca.

The specialization and mechanization of modern crop production seem to unduly restrict the agricultural exploitation of potentially useful regions. The archaeological reconstruction of the prehistoric technology utilized in the exploitation of these lands may provide modern populations with an expanded economic base, as well as providing increased food production for those populations confined to such "marginal" lands.

The present distribution of salinated soils (Solonchaks) may well be a function of the long history of irrigated agriculture in the Chicama Valley (Watson and Kluge 1978:22). A comparison of prehistoric settlement distributions within the lower valley would undoubtedly be very useful in determining whether or not this is the case. Unfortunately, surveys in this region have not been intensive enough to allow any conclusive statements as to the validity of this hypothesis.

The ONERN (1973) study of soil distribution in the Chicama

Valley is of a very general nature and provides only a broad outline of soil characteristics. This large-scale classification tends to obscure soil differences which may have been significant to prehistoric agriculturalists. Small areas of cultivable land along prehistoric maximum elevation canals, for example, often appear to have been cultivated in spite of the fact that the vast majority of the soils in the area had little or no agricultural value. The comparison of even these broad classifications with areas of prehistoric cultivation, however, can still provide useful information on prehispanic agricultural patterns and technology.

The importance of soils to agriculturally based societies, regardless of their level of socio-cultural development, should not be underestimated. The productive capabilities of any such society are intimately tied to the productive potential of the soils available for their exploitation. In the case of the late prehistoric period in the Chicama Valley, the exploitation of the different soil types seems to have been less restricted than it is now. In later chapters, I will discuss the agricultural technology available during the late prehistoric period to exploit the soils found in the lower valley and will illustrate the areas and soils utilized by the prehistoric populations of the Chicama Valley (see Map 4).

CLIMATE

The climate of the north coastal valleys as a whole is very uniform. This general climatic uniformity has been attributed to the influence of the sub-tropical highs, the Humboldt Current, and the Andes (Howell 1952, 1953; Trewartha 1961; W.E. Howell Associates 1953). The general climatic pattern which results from the interaction of these factors is one of a cool, dry desert with a high average annual cloud cover (Johnson 1976; Trewartha 1968). The climate of the Chicama Valley fits this pattern very well.

Significant rainfall is limited to the higher elevations. Quantities sufficient to allow non-irrigated agriculture occur only above about 2000 meters. The occurrence or non-occurrence of rainfall in the upper valley is governed largely by air mass characteristics associated with the large-scale weather situation (Howell 1952). It is these characteristics of "... the stability relationship between the modified Pacific air and the overlying easterlies..." and "... the moisture and stability within each air-mass" (Howell 1952:41) which ultimately determine the amount of water available to the lower valley.

In an attempt to increase the available water in the valley, a program of cloud seeding was instituted in the upper valley in 1951. It is estimated that the program increased the total annual rainfall from 12 percent to 15 percent in a limited portion of the upper valley (Howell 1965). The effect which this had on the water

available to the lower valley and its implications for environmental reconstruction will be discussed in the following chapters.

The data recorded by the four meteorological stations in the lower Chicama Valley reflect the extremely dry climate of this region (see Table 5).

Station	Elevation (meters mean sea level)	Average Annual Temperature: Years of Record	Average Annual Precipitation: Years of Record
Puerto Chicama	4 mmsl	21.4°C: 1926-68	5.5 mm: 1945-69
Cartavio	51 mmsl	20.3°C: 1946-70	13.1 mm: 1944-70
Chiclin	117 mmsl	21.7°C: 1957-60	21.7 mm: 1958-60
Casa Grande	150 mmsl	20.9°C: 1934-70	16.4 mm: 1934-70

Table 5. Average annual temperature and precipitation at selected stations in the lower Chicama Valley.

Such limited rainfall restricts all cultivation in the lower valley to those areas which can be supplied with water from either the Chicama River or the shallow water table.

Any discussion of the long-term climate of the North Coast must include a mention of the El Niño phenomena. The term El Niño actually refers to several related oceanic and atmospheric phenomena which occur at irregular intervals.

The exact relationships between these phenomena are not well understood. Recent evidence indicates that the oceanic phenomena associated with an El Niño occur when there is a substantial (4°-6°C) increase in the ocean temperature (Wooster and Guillen 1974:394).

Several hypotheses have been offered to explain this sudden rise in temperature (Caviedes 1975; Johnson 1976; Lettau 1976; Wyrtiki 1975). The temperature and salinity differences associated with an El Niño drastically alter the marine environment causing the widespread destruction of plankton, fish, and guano birds. The atmospheric phenomena of increased moisture, due to increased evaporation, and large-scale atmospheric dislocations, bring rains to the normally desert coast. The extent, magnitude, and frequency of these rains exhibit a wide range of variation. In his description of the 1925 El Niño, Murphy (1926) refers to the possibility that the occurrence of these phenomena is cyclical:

> El Niño, the warm countercurrent, is a well known phenomenon in northern Peruvian waters, commonly appearing about Christmas time and flowing southward. The more or less annual effects of the countercurrent are, as a rule, observable only in northernmost Peru. During a longer cycle, traditionally believed to be seven years, but less evident recently than in former times, its manifestations are more pronounced and extensive. At still longer intervals, representing in the present instance a rhythm of thirty-four years, El Niño and its associated phenomena attain their maximum expression (Murphy 1926:27).

The present evidence is not sufficient to support or deny the cyclical nature of these phenomena, particularly in the case of the large, less frequent occurrences.

The most recent major El Niño occurred in 1972, but was smaller and affected less of the coast than the 1925 or 1891 phenomena. The extent, magnitude, and frequency of prehistoric

El Niño phenomena certainly exhibited similar variations. With a heavy reliance on agricultural production and marine exploitation for food and resources, the coastal populations would have been greatly affected by both the atmospheric and oceanic phenomena.

Archaeological evidence of El Niño phenomena have been discovered by several investigators in the Chicama and Moche Valleys (Kus, et al. 1977; Larco Hoyle 1938-39; Schaedel 1951b). This evidence, in the form of "flood caps" and damage to irrigation systems may provide a means by which the distribution, frequency, and magnitude of past phenomena can be determined. In addition, archaeological evidence can provide an opportunity to investigate the impact of large-scale environmental catastrophy on societies at different levels of socio-cultural development. In several ways, the El Nino presented to the inhabitants of the North Coast a major climatic force as significant as the pervasive aridity which normally dominates the region.

In addition to the flooding associated with the El Niño rains, some quebradas experience occasional flash floods, or huaicos. Huaicos are the result of localized rainfall in the upper reaches of large quebradas and are not necessarily associated with periods of excessive rainfall on the coast. A preliminary evaluation of aerial photos of the Chicama and Moche Valleys indicates that several quebradas contain structures which may have served to control floods. A study of these and similar structures on the North Coast could shed light on prehistoric flood control technology and potentially on the

periodicity of the El Niño phenomena, as well.

HYDROLOGY

The total reliance on surface and subsurface water for agriculture in the lower valley points to the extreme importance of the seasonal and annual variations in the flow of the Chicama River. Records of the monthly and annual discharge of the Chicama have been kept for over fifty years and provide valuable information on the availability of water for irrigation in the lower valley.

The Salinar hydrologic station in the Chicama Valley is located about 49 kilometers from the coast at an elevation of 330 mmsl. This location is above the bocatomas, or intakes, of the major canals supplying water to the alluvial plain. Only a small portion (1577 hectares, 1.5 percent) of the study area is located above this point.

As was noted earlier, a program of cloud seeding was carried out in the upper valley. This program consisted of silver iodide seeding from ground based generators at about ten different stations in the upper Chicama Valley between the years of 1951 and 1963. During this period, it was estimated that rainfall in this part of the valley increased from 12 to 15 percent over the previous twelve years (Howell 1965).

It is logical to expect that a similar increase would be seen in the total annual discharge of the Chicama River. This is not the case, however. A non-parametric analysis of variance (Kruskal-Wallis Test) indicates that for the thirty-three years tested (twenty-one unseeded versus twelve seeded) there was no

statistically significant change in total annual discharge measured at the Salinar hydrologic station (see Table 6 and Fig. 1). Several factors may have contributed to these results. An increase in the amount of water withdrawn from the river above the hydrologic station and the increased diversion of surface runoff prior to its reaching the river may account for the lack of increased discharge during the seeded years.

This explanation receives support from the fact that between 1951 and 1963, one of the companies sponsoring the cloud seeding program increased the amount of irrigated land in the upper valley from 14,000 hectares to 18,500 hectares (Howell 1965:700). An increase in both the rainfall and the amount of land irrigated in the upper valley resulted in no significant change in the total river discharge measured at the Salinar hydrologic station.

The seasonal and annual distribution of river discharges is not uniform, as may be seen in Fig. 2 and Table 7 . The seasonal distribution of river discharges is characterized by a high rate of discharge from about mid-January to the end of April, followed by a rapid decline in discharge to a low, occurring some time from October to December. On the average, 86 percent of the total annual discharge occurs in only five and one-half months out of the year, with 74 percent concentrated in the period from mid-January to the end of April. This period corresponds to the southern hemisphere's summer and is consequently the period when irrigation requirements are at their highest. The annual variation in the discharge of the

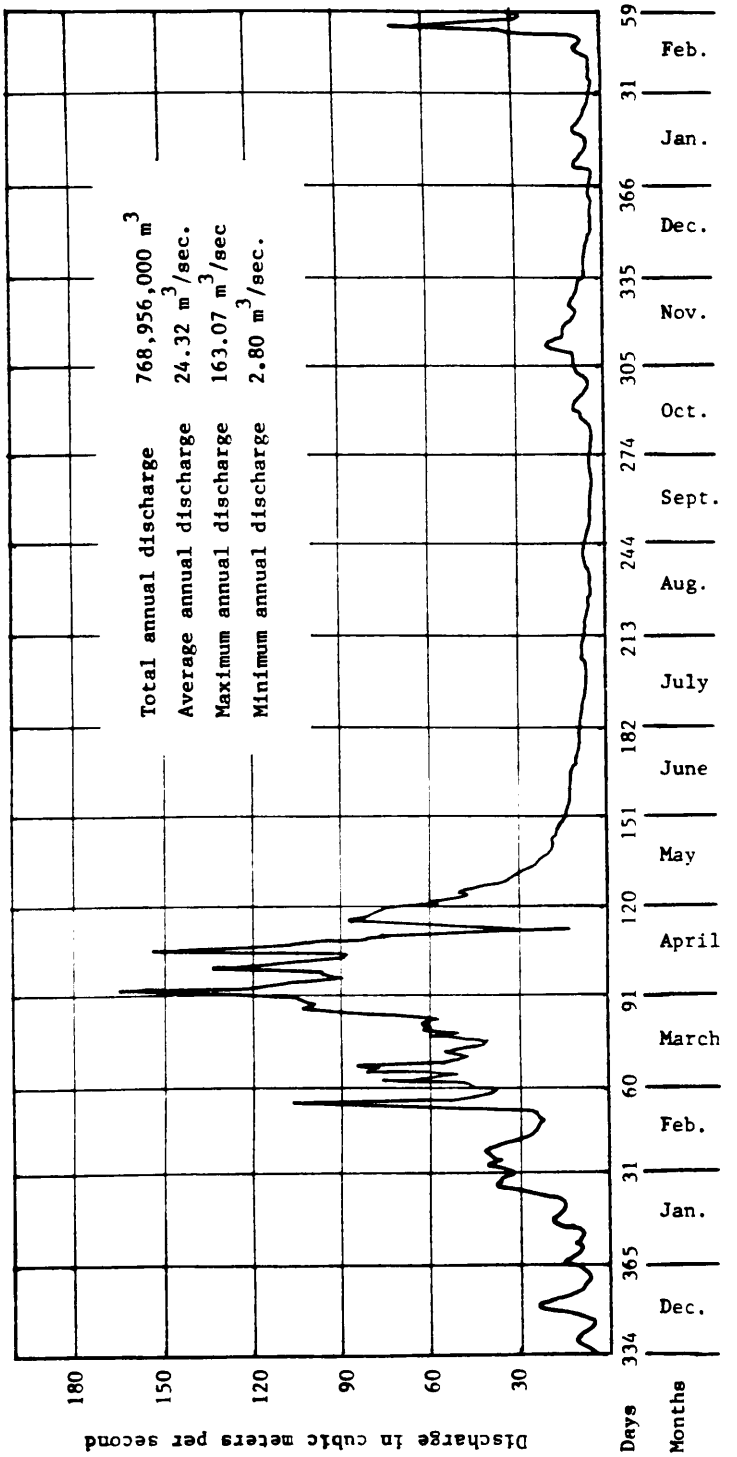


Figure 1. Hydrograph of 1964 daily discharge of the Chicama River, adapted from ONERN (1973 Grafico no. 3. page 202).

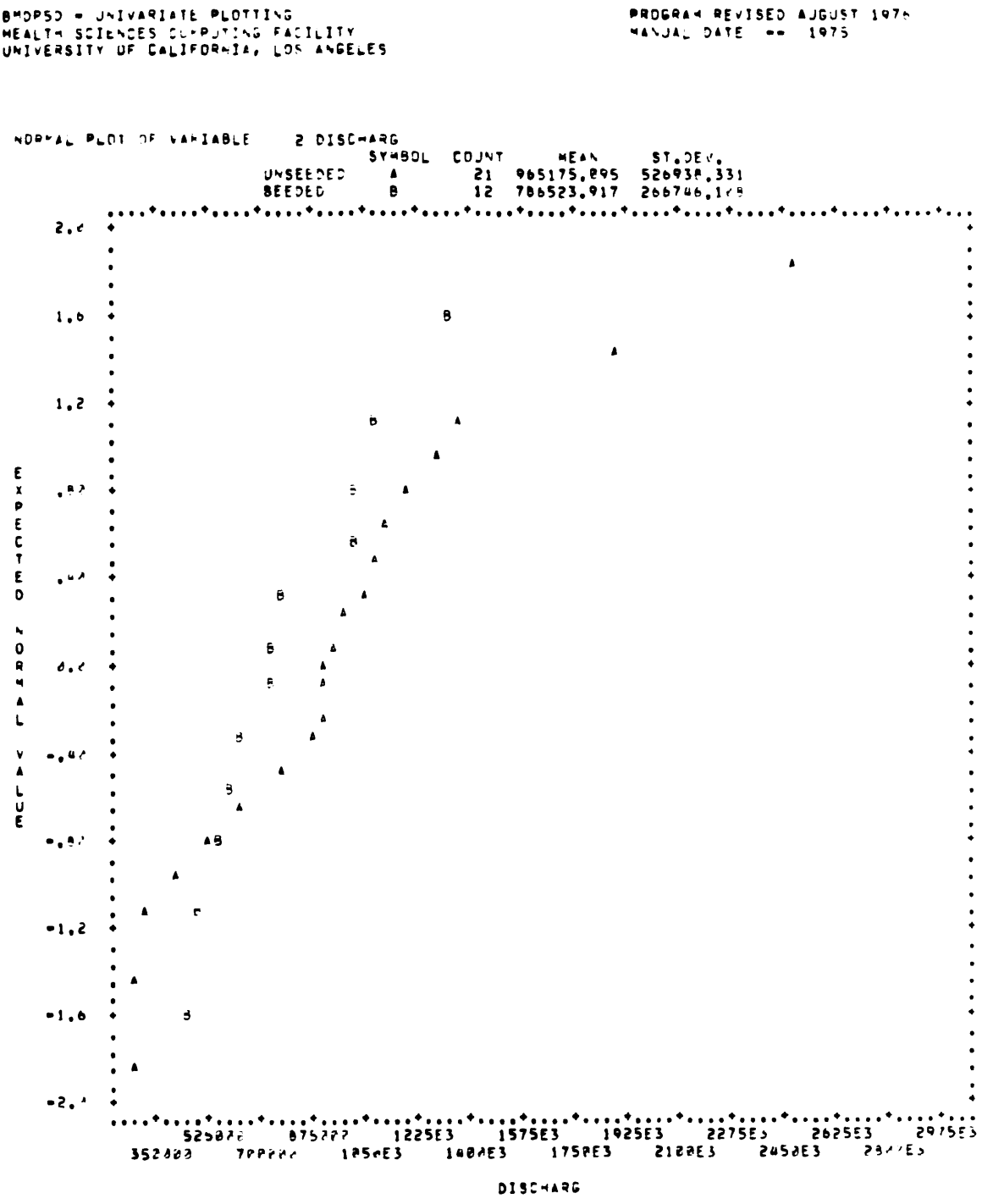


Figure 2. Normal plot of the Chicama River discharge for the unseeded (A: 1930-1951) and the seeded (B: 1951-1963) years. The departure of the plots from straight lines indicates that the data are not normally distributed.

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S P S S - - STATISTICAL PACKAGE FOR THE SOCIAL SCIENCES

CDC 6600/CYBER 72 VERSION 7.0 - INSTALLED 25 APR 79

NONPARAMETRIC ANOVA OF RIVER DISCHARGE: UNSEEDED VS SEEDED YEARS

FILE   1        (CREATION DATE = 02 JUN 79)

- - - - - KRUSKAL-WALLIS 1-WAY ANOVA

    DISCHAR
 BY SEEDING

                UNSEEDED    SEEDED
  SEEDING              1         2
   NUMBER             21        12
MEAN RANK           18.2      14.8

                                                  CORRECTED FOR TIES
         CASES   CHI-SQUARE  SIGNIFICANCE   CHI-SQUARE  SIGNIFICANCE
            33       .9468         .3305        .9468         .3305

- - - - - MANN-WHITNEY U - WILCOXON RANK SUM W TEST

                    UNSEEDED = 1                SEEDED = 2
    DISCHAR       MEAN RANK        NUMBER     MEAN RANK        NUMBER
 BY SEEDING            18.2            21          14.8            12

                                    EXACT              CORRECTED FOR TIES
          U           W       2-TAILED P          Z       2-TAILED P
      152.0       178.0            .3452       .9730            .3305
```

Table 6. Kruskal-Wallis nonparametric analysis of variance, comparing the unseeded (1930-1951) Chicama River discharge to the seeded (1951-1963) discharge. The non-normal distribution of the data (see fig. 1) dictated the use of a nonparametric analysis of variance.

Table 7. Summary of discharge characteristics of the Chicama River: 1931-1970.*

Discharge recorded at Salinar Hydrologic Station:

Location: Longitude: 78° 53'

Latitude: 7° 40'

Altitude: 330 mmsl

Area of the drainage above the Hydrologic Station:

Total Area: 3,642 square kilometers

Description of Discharge		MONTHS											
		January	February	March	April	May	June	July	August	September	October	November	December
Maximum Daily Average	m^3/sec.	157.54	375.14	144.16	433.44	174.44	25.03	15.85	14.01	21.39	36.03	66.34	131.41
Maximum Monthly Average	m^3/sec.	93.26	157.10	469.84	244.77	61.48	17.38	11.01	7.97	10.25	12.88	17.45	44.27
		22.13	50.24	101.51	75.69	27.00	10.81	6.77	4.77	3.92	4.87	5.34	7.94
Minimum Monthly Average	m^3/sec.	1.76	4.40	14.33	9.38	3.07	2.24	1.69	1.28	0.74	1.33	1.62	1.55
Minimum Daily Average	m^3/sec.	0.75	0.75	3.88	3.40	2.27	1.98	1.25	0.92	0.50	0.52	0.80	0.51
Difference of Monthly Average Extremes	m^3/sec	91.50	152.70	455.51	235.39	58.41	15.14	9.32	6.69	9.51	11.55	15.83	42.72

	26.60 m^3/sec.	Maximum Recorded Discharge	1,441.16 m^3/sec.	Average Annual Volume	839'432,000 m^3
Maximum Average Annual Discharge	78.74 m^3/sec.			Maximum Annual Volume	2,483'174,000 m^3
		Minimum Recorded Discharge	0.50 m^3/sec.		
Minimum Average Annual Discharge	4.10 m^3/sec.			Minimum Annual Volume	129'730,000 m^3

* Adapted from ONERN (1973:Cuadro no. 2-RH,page 199).

Chicama Valley is very substantial, ranging from 2,666,975 x 10^3 cubic meters in 1925 to 264,130 x 10^3 cubic meters in 1950.

The unconsolidated alluvial materials of the lower valley act as a large subsurface reservoir which stores substantial amounts of fresh water, estimated to be 165,000 x 10^3 cubic meters (ONERN 1973: 208). However, the utilization of this volume of subsurface water requires the use of well and pump technology which was not available to the prehistoric inhabitants of the Chicama Valley.

When dealing with irrigated agriculture in an arid environment, it is always necessary to bear in mind the problem of soil salinization. The effects of failure to adequately deal with this problem are well illustrated by Jacobsen and Adams (1958). A very important aspect of this problem is the quality of the water being used for irrigation.

The chemical quality of irrigation water is a function of four factors. Probably the single most important chemical factor is the total concentration of dissolved solids. Total concentration is measured in parts per million (ppm) or as electrical conductivity (EC) in micromhos per centimeter (EC mho/cm). The latter is the generally preferred method. Plant growth can be greatly impaired or prevented by excessive salts in irrigation waters.

Sodium (Na+) concentration is important because of the adverse chemical and physical conditions which develop in the soil when exchangeable sodium is present, even in relatively low concentrations. The sodium-absorption-ratio (SAR) is the most reliable

index of exchangeable sodium in irrigation water and is expressed in milliequivalents per liter (meq/l) (Wilcox and Durum 1967:109).

Bicarbonate (HCO_3^-) is significant for its chemical reactions with calcium (Ca^{2+}) and magnesium (Mg^{2+}) which increase the relative proportion of sodium and its attendant hazards. Bicarbonate is evaluated in terms of the residual sodium carbonate (RSC) which serves as an index of the sodium hazard relative to the bicarbonate concentration.

The fourth factor which is significant in terms of the chemical quality of irrigation water is phytotoxic substances. In most cases, this refers to the concentration of boron which is measured in parts per million. Other trace elements, however, may be locally significant.

Taking into account the first two of these factors, the U.S. Salinity Laboratory (1954) developed a classification system for irrigation water (see Appendix 3). Once this classification has been made, the concentrations of bicarbonate and phytotoxic substances should be evaluated to determine the suitability of a water source for irrigation purposes.

Just such an evaluation was carried out on water from ten locales in the Chicama Valley in 1971 (ONERN 1973). The results of this analysis indicated that in nine of the ten cases, the water could be classified as having only a medium salinity (C2) and a low sodium (S1) content. In the tenth case, the water was classified as having a high salinity concentration, but a low sodium concentration.

This sample was collected from the mouth of a large canal which is located below several drainage canals which discharge excess irrigation water back into the river. Under these circumstances, it is not surprising to find a higher salinity in this canal. No samples were taken any farther downstream, but it is likely that this trend of increasing salinity would continue. None of the samples contained significant concentrations of either bicarbonate or boron.

This analysis indicates that with a moderate amount of leaching, no problems of salinization are likely to occur in the upper section of the lower valley. However, as runoff is recycled for use in the lower portions of the valley, care must be taken to provide adequate drainage, and the use of salt tolerant plants is recommended.

There is no reason to believe that the quality of irrigation water would have been worse during the prehistoric period than it is now. Under these circumstances, only a moderate amount of additional irrigation would have been necessary to prevent soil salinization in a large part of the valley. Salinization may have become important during the period of maximum agricultural expansion, however. With the allocation of additional water to expanded fields, the amount necessary for proper leaching may not have been available to all of the fields. This could have been particularly significant in the lower valley where the soils are less well drained and the water of poorer quality. As I noted in my discussion of soils, however, the use of specialized technology allowed the successful exploitation of

salinated areas. The concentration of late prehistoric populations in these areas seems to indicate that adaptation to saline lands was relatively effective.

The seasonal and annual variations in the discharge of the Chicama River must have played as significant a role in the agricultural system of the late prehistoric population as they do today. In all likelihood, they were more significant because of the lack of modern well and pump technology for the exploitation of subsurface water.

It has been suggested that the prehistoric agriculturalists of the North Coast found means to mediate the impact of the seasonal and annual variations in discharge. Kosok (1965:95) has suggested that areas or "pockets" of land outside of the areas cultivated in a "normal" year were prepared for cultivation by the construction of canals and fields which would be cultivated only during times of high discharge. In this manner, excess water could be diverted into these marginal fields during periods of peak flow and a crop produced on what might normally be uncultivated land.

Another suggestion is that in certain locations artificial reservoirs were constructed in order to impound excess water during periods of high river discharge for release during the drier parts of the growing season (Rodriguez Suy Suy 1971).

The use of subsurface water for agricultural production has a long history on the North Coast (West n.d., 1978, 1979). During the prehistoric period, the utilization of this resource was limited

to the use of walk-in wells, mahamaes (sunken fields), and in the case of natural seeps, to the use of canals to redirect the flow into fields (Day 1974; Moseley 1969; Parsons 1968; Parsons and Psuty 1975; Rodriguez Suy Suy 1971; Rowe 1969; West n.d., 1978, 1979). These structures were restricted in their use to areas where the water table was within only a couple of meters of the surface. For this reason, they were frequently located near the coastline and along the river channels in the lower valleys. Mahamaes cultivation consisted of fields which were excavated down to or just above the surface of the water table. In this way, water was supplied directly to the root zone of the crops by the artificially shallow water table.

MODERN ENVIRONMENT AND PALEO-ENVIRONMENTAL RECONSTRUCTION

The combination of climate, topographic, and biological factors on the coast and western slopes of the Andes has produced a vertical stratification of unique microenvironments.

The pioneering work on the ecology of the Peruvian Andes was conducted by A. Weberbauer and appeared in several German publications during the first quarter of this century and in Spanish translation in 1945 (Weberbauer 1945). An English summary and supplement of this work is found in Part 1 of Macbride's (1936) extensive description of the flora of Peru. More recently, the Koepckes (1951) and J.A. Tosi (1960) have studied the ecology of the western slopes of the Andes.

The most complete treatment of the environmental zones specifically in the Chicama Valley appears in a recent study by the Oficina Nacional de Evaluacion de Recursos Naturales (ONERN 1973). In this study, the life zone system developed by L. R. Holdridge (1947, 1959, 1966, 1967) has been applied to the valley. The ONERN study included some minor modifications consisting of the subdivision of each natural life zone into use areas.

The life zone system was developed by Holdridge in an attempt to define a basic unit of analysis for ecological studies. This system is based on a quantification of three major climatic factors: heat, precipitation, and moisture. For the purposes of this model, heat is defined in terms of the mean annual biotemperature:

> The biotemperature mean is an average of the

> Celsius temperatures at which vegetative growth takes place relative to the annual period. The range of temperatures within which vegetative growth occurs is estimated to lie between $0^{o}C$ as a minimum and $30^{o}C$ as a maximum. The positive temperatures within this range must be averaged out over the whole year period in order to make it possible to effectively compare a given site with another on the earth (Holdridge 1967:18).

The second climatic factor of precipitation is defined as the mean annual total of precipitation in millimeters, excluding moisture which condenses directly on the vegetation or ground. This moisture was excluded because it is not normally recorded by standard meteorological stations and is not available for large parts of the world, which severely limits its utility in a global classification system.

The final climatic factor used to determine the boundaries of life zones is humidity. This factor is defined in terms of the potential evapotranspiration ratio. The potential evapotranspiration in millimeters per year is defined as being equal to the mean annual biotemperature multiplied by the factor 58.93 (Holdridge 1959, 1967).

$$PE = 58.93 \times t^{(bio)}$$

The potential evapotranspiration ratio is calculated by dividing the mean annual potential evapotranspiration (as calculated using the above formula) by the value of the mean annual precipitation in millimeters.

The values for these three factors are then entered into a nomogram which, in conjunction with latitudinal and altitudinal information, define the appropriate natural life zone. Appendix 4

illustrates this procedure for two zones found in the Chicama Valley.

Six natural life zones have been defined in the Chicama drainage (ONERN 1973; Tosi 1960) (see Fig. 3 and Table 8). These zones have been further subdivided into sixteen use areas on the basis of their current exploitation patterns. Only the lowest zone, the Premontane Desert and its five associated use areas are of concern in this report. All of the remaining zones are located at elevations above 400 mmsl and are not included in this study.

The Premontane Desert life zone is characterized by an average annual temperature of from 20°C to 21°C with an average annual precipitation between 5 millimeters and 100 millimeters. The elevation in this zone ranges from sea level to 600 meters, and the topography ranges from flat to very rugged and dissected. Eutric Fluvisols dominate, and with some areas of Gleyic Solonchaks, compose the majority of the soils found in the alluvial plain of this zone. Eutric Regosols and Lithosols comprise most of the rest of the soils found in this zone with only a very limited area of Orthic Solonchaks (see Fig. 3).

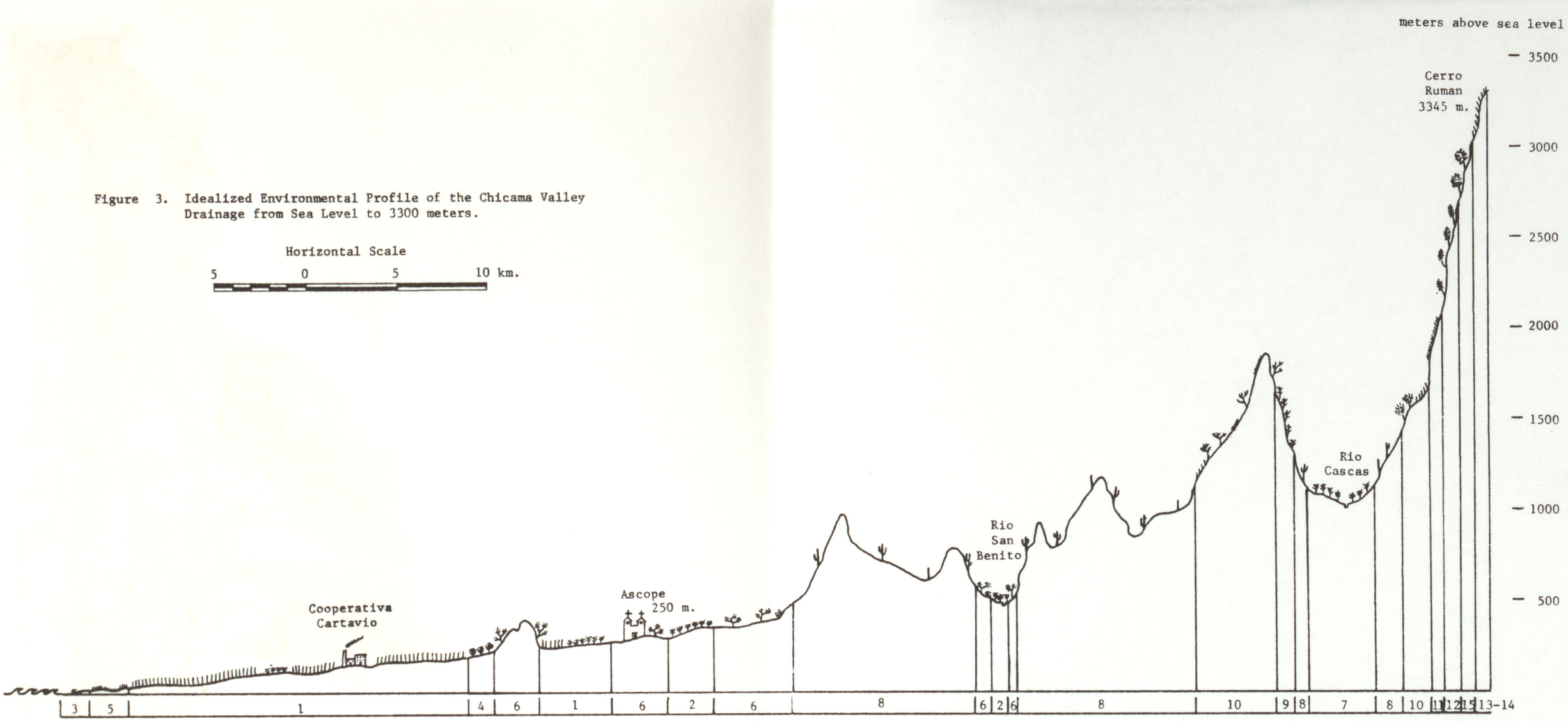
The six use areas of this zone, as defined in the ONERN study (1973) are:

1. The agricultural area of the coast - comprises an area of approximately 45,590 hectares of land under permanent irrigation. The vast majority of this area is devoted to the intensive cultivation of sugar cane, with some limited areas devoted to food and forage crops. All but about 300 hectares of this area are

Figure 3. Idealized Environmental Profile of the Chicama Valley Drainage from Sea Level to 3300 meters.

Horizontal Scale

5 0 5 10 km.



KEY TO ENVIRONMENTAL ZONES AND USE AREAS

ENVIRONMENTAL ZONES	USE AREAS
PREMONTANE DESERT	1 COASTAL DESERT -largely agricultural
	2 DESERT - agricultural areas in quebradas
	3 DESERT - uncultivated pampa
	4 DESERT - forests
	5 DESERT - salinated areas, including poorly drained local depressions
	6 DESERT - hills and plains
PREMONTANE DESERT SCRUB	7 DESERT SCRUB - agricultural area of piedmont and quebradas
	8 DESERT MOUNTAINS - unused
PREMONTANE THORN WOODLAND	9 Hilly agricultural area of piedmont and quebradas
	10 Hilly area - seasonal vegetation
LOWER MONTANE DRY FOREST	11 Mountainous dry forest - agricultural area of piedmont and hills
	12 Mountainous dry forest - shrubs and high thickets
MOIST MONTANE PLAINS (FOREST)	13 Moist mountain plains - agricultural area on slopes
	14 Moist mountain slopes - diverse vegetation
	15 Moist mountain slopes - diverse vegetation and forests

Table 8. Summary of Environmental Zones and Use Areas

		Range of Elevation (meters above sea level)	Average Annual Temperature (°C)	Average Annual Precipitation (mm)	Dominant Type of Topography	Dominant Soil Type	Dominant Natural Vegetation	Comments
1	Coastal Desert - largely agricultural area	0 - 400	20°- 21°	5 - 20	flat	alluvial, deep and fertile	xerophytic	very dry - agriculture impossible without irrigation
2	Desert - agricultural area in quebradas	400 - 500	20°- 21°	20 - 100	flat to rolling	colluvial and alluvial; moderate depth and fertility	xerophytic	very dry - agriculture impossible without irrigation
3	Desert - uncultivated pampa	0 - 600	20°- 21°	5 - 100	flat to rolling	aeolian, some alluvial; moderate depth, fertile	xerophytic and epiphytic	very dry - agriculture impossible without irrigation
4	Desert - residual and/or artificial forests	100 - 200	20°- 21°	5 - 20	flat	alluvial and aeolian; moderate depth and fertility	residual and/or artificial forests; bushes and shrubs	very dry - agriculture impossible without irrigation
5	Desert - areas of salinization; poorly drained local depressions	0 - 30	20°- 21°	5 - 8	flat to rolling	aeolian; excessive salinization, poor drainage, infertile	halophytic; rushes and reeds in depressed areas	possible source of totora reeds; no other agricultural potential; extent partially due to irrigation
6	Desert - hills and plains	500 - 600	20°	20 - 100	flat to very rough	residual and aeolian; thin, rocky and infertile	scant xerophytic; biotic activity scarce	may appear in isolated areas to 1000 m.
7	Desert Scrub - agricultural areas of piedmont and quebradas	500 - 1300	20°	100 - 200	rolling, with occasional cliffs	colluvial, some aeolian; moderate depth and fertility	columnar cactus especially below 1000 m.; seasonal shrubs	agriculture impossible without irrigation, some seasonal vegetation
8	Desert Mountains - some pasturage, largely unused	500 - 1300	20°	100 - 200	very rough	residual and lithosols; very thin and rocky, low fertility		
9	Hills - agricultural area of piedmont and quebradas	1200 - 2100	18°- 20°	230 - 890	rough	colluvial and residual; variable depth, fertility good to medium	seasonal vegetation and shrubs; trees along watercourses	upper part of this zone is lower limit of rainfall agriculture; climate temperate above this zone
10	Hills - seasonal vegetation	1200 - 2100	16°- 18°	230 - 890	very rough	residual; thin, low fertility	seasonal thickets and grasses; some trees	upper part of this zone is lower limit of rainfall agriculture; climate temperate above this zone
11	Mountainous Dry Forest - agricultural area of piedmont and quebradas	2000 - 2800	14°- 16°	400 - 800	fairly rough	residual; moderate depth, fertile	seasonal grasses; shrubs along watercourses	moderately intense rains December to April
12	Mountainous Dry Forest - shrubs and high thickets	2000 - 2800	12°- 14°	400 - 800	rough	residual; variable depth, moderate fertility	seasonal grasses; shrubs and trees along watercourses in thickets	moderately intense rains December to April
13	Moist Mountain Plains - agricultural area on mountain slopes	2700 - 3800	10°- 12°	900 - 1400	rolling, with shallow quebradas	residual; deep and fertile	extensive meadows; intermittent trees and shrubs	climate moist and cool in and above this zone; intense rains October to May
14	Moist Mountain slopes - diverse vegetation	2700 - 4000	8°- 10°	900 - 1400	rolling, with shallow quebradas	residual; deep, moderate fertility	diverse vegetation; grasses, shrubs, dense stands trees, extensive meadows	intense rains October to May and occasionally in other months
15	Moist Mountain Slopes - forests and diverse vegetation	2700 - 4000	8°- 10°	900 - 1400	rough, with quebradas	residual; variable depth, moderate fertility, areas of erosion	diverse grasses and shrubs, forest areas in quebradas	deer, and possibly bear, present; rains concentrated in period October to May

included in this study.

2. The agricultural area of the quebradas - comprises an area of only 450 hectares in the central valley. This area is primarily devoted to the semi-intensive cultivation of rice and other food crops under permanent irrigation. None of this use area is included in this study.

3. The uncultivated pampa - includes an area of 50,650 hectares of which 27,950 are estimated to be potentially irrigable and subject to intensive agriculture and forestation. This area is presently out of production due to the lack of water for irrigation.

4. Residual and/or artificial forests cover an area of 4800 hectares.

5. Areas of salinization - comprise some 2750 hectares in the lower alluvial plain near the coast. These serve as limited areas of light pasturage for livestock and for the harvesting of totora reeds, Scripus tatora. In addition, recent studies by Rodriguez Suy Suy (personal communication) have shown that these areas are being brought under cultivation using a ridged field system in conjunction with such salt tolerant cultigens as the squashes and indigenous cottons.

6. Pampas and hills with very scarce xerophitic vegetation - comprise an area of 66,100 hectares. The area might more properly be termed a no-use zone. It exhibits very limited biotic activity and, in many areas, no soil development. Parts of the area may be useful for furnishing raw materials such as stone, sand, and

clay, and in some areas, the plant Tillandsia sp. which was collected as a fuel (Lechtman and Moseley 1975).

These six use areas are, of course, based on the modern land use in the Coastal Desert life zone (see Fig. 3). A reconstruction of prehistoric exploitation patterns of these areas is briefly outlined below.

Area 1 appears to have functioned as the agricultural core or "breadbasket" of the prehistoric coastal populations. Area 2 and portions of Area 3 also contributed to the agricultural production of the prehistoric peoples. Area 4 also appears to have included agricultural areas, as well as supplying necessary wood and fuel.

Area 5 is a largely marginal part of the valley today, but very likely played a significant role during the prehistoric period. The saline groundwater which occurs in this area nearest to the coast produces salt pans which were exploited as a source of salt during the prehistoric period (Netherly 1977:60-64). The hunting of both resident and migratory waterfowl also seems to have been a significant aspect of the exploitation of this area. Netherly (1977: 67-69) has suggested that the lagoons found in this area were enlarged and managed as a source of fish (mullet - Mugil cephalus) and totora reeds (Scripus tatora). Totora reed was an important industrial plant used in the construction of reed boats and rafts and as a building material. In addition to these uses, this area contains the remains of prehistoric excavated fields. The artificially shallow water table in these fields provided a reliable source of

water which allowed a more continuous cultivation than could be obtained on much of the land irrigated by canals. Mochica iconographic representations of the flora and fauna indigenous to Area 5 and the presence of archaeological sites within and adjacent to this area illustrate its significance during the prehistoric period. Unfortunately, dating of the sunken fields and associated sites must await further field work.

Area 6 includes a significant number of locations which show evidence of prehistoric use. Habitation, ceremonial, administrative, and cemetery sites are located in this area, particularly where they are adjacent to areas of cultivation (Watson and Kluge 1978).

As may be seen from this brief summary, the exploitation of specific areas in the lower Chicama Valley has, in the case of Area 1, changed only in the form, but not the type of exploitation, while the exploitation of Areas 5 and 6 has altered significantly from the prehistoric period to the present.

Before these types of comparisons may be considered as valid, however, it is necessary to determine whether there has been any significant environmental change during the periods under comparison. Unfortunately, no paleoenvironmental reconstructions are available for this part of the North Coast. Research in the Talara region of extreme northwest Peru and on the Santa Elena Peninsula of southwestern Ecuador indicates that this region has experienced several periods of fluctuating precipitation and aridity during the last 8,000 years (Paulsen 1976; Richardson 1973; Sarma 1974).

On the basis of archaeological evidence for repopulation of the Santa Elena Peninsula, McDougle (1967), Paulsen (1976), and Richardson (1973) have postulated a period of increased precipitation from A.D. 1000 to 1400. Sarma (1974), however, was unable to confirm the existence of such a period from his analysis of the molluscan faunal remains. With the distances involved, over 400 kilometers, and the apparent uncertainty of the environmental reconstruction for the period of concern, it is not appropriate to uncritically apply these reconstructions to the Chicama Valley. Therefore, in order to mediate these difficulties, the basic assumption will be made that no major environmental changes have occurred in the climate of the Chicama Valley for the past 1000 years.

CULTIGENS

In any system of agriculture, the cultigens utilized and the agricultural technology employed in their cultivation represent an adaptation to human nutritional requirements, cultural prescriptions, and environmental limitations. If the individuals of a society and, hence, the society itself, are to survive, the subsistence system must provide certain minimal nutritional requirements. As a part of the subsistence system, agriculture provides varying percentages of these requirements in different societies.

By defining the limits of the agricultural system for a given society, we begin to define the scope of the larger subsistence system. From this system we may ultimately make population estimates and derive the societal and cultural implications of a tremendous variety of subsistence systems.

Agricultural systems should not be restricted to inclusion only in subsistence systems. Cultural prescriptions impose requirements for certain raw materials (such as cotton) which are also produced by agriculture. Other prescriptions apply to the production of food products which never enter the subsistence system. An example of this case would be the production of yams in Ponape which are placed on display and allowed to rot as a culturally defined means of increasing the owner's prestige (Bascom 1948:212).

Environmental limitations might more accurately be described as adaptive limitations. In reality, it is not the environment which limits the scale and productivity of the agricultural system, but the

level of technological and social adaptation to the environment. Technological adaptations include the techniques employed in the actual land preparation, planting, growth maintenance, harvesting, and post-harvesting activities. Social adaptations include the development of social institutions to provide the necessary input of energy to maintain and expand the agricultural system as a whole.

The prehistoric cultigens of Peru represent culturally selected, and in the case of domesticated varieties, modified organisms which meet the requirements and limitations briefly outlined above. These requirements and limitations are, of course, specific to particular locales and societies. Environmental limits, for example, preclude the cultivation of olluco (Ullucus tuberosus) at the low elevations of concern in this study. These limits would effectively remove this particular cultigen from the agricultural system of interest here, but would not, of necessity, remove it from the larger subsistence system. For example, olluco has been found in archaeological contexts on the coast (Towle 1961:37). This would indicate that in some regions, at least, olluco may have been included in the subsistence system of coastal populations.

Three kinds of evidence are useful in the reconstruction of prehistoric plant domestication and use in Peru. Ethnohistoric evidence consists of the descriptions of plants used by the Incas and other indigenous peoples of Peru as they appear in the writings of the early chroniclers. Cieza de León, Garcilaso de la Vega, Bernabé Cobo, and others included much information

regarding not only the plants themselves, but also their uses. Bernabé Cobo produced one of the earliest and most complete descriptions available of plants and their use in Peru. Yacovleff and Herrera (1934-35: 69) list Cobo as having described twenty-five plants for the first time, as well as many others mentioned in less detail by earlier writers.

The second kind of evidence which has proven to be useful is iconographic representations found on pre-Columbian sculpture, painting, and ceramics. Particularly useful are the three-dimensional representations on the ceramic vessels of the Mochica and Chimu periods of the North Coast and the painted depictions on Nazca period ceramics of the South Coast. Yacovleff and Herrera (1934-35) used iconographic representations in conjunction with ethnohistoric evidence to establish the antiquity of the use of specific plants in ancient Peru.

The third kind of evidence which has been applied to the reconstruction of plant domestication and use is archaeological. Archaeological evidence consists of actual plant remains recovered from an archaeological context. Due to the very dry climate, the preservation of plant remains is very good on the coast. As a result, remains recovered from archaeological contexts have contributed much to our understanding of the prehistoric use of plant materials in Peru.

Each of these lines of evidence has inherent weaknesses which must be made explicit if we are to avoid certain pitfalls. The primary difficulty encountered with ethnohistoric data is the problem of accurately identifying exactly which plant is being discussed. Few chroniclers provided detailed descriptions of those parts of the plant

most important to modern plant taxonomists. Only through a thorough knowledge of the regional species and a careful comparison to ethnographically described economic plants can useful determinations be made from ethnohistoric sources. Such evidence of plant usage, like all ethnohistoric evidence, is most useful in dealing with the population for which it is described. As the temporal distance between the ethnographic present recorded by the chroniclers and the time period under study increases, so does the uncertainty of the evidence. In like manner, as the spatial distance increases, the reliability of ethnohistoric and ethnographic evidence decreases dramatically. Spatial distances are very significant in this regard. Due to vertical stratification, short distances separate very different environments, and hence, adaptations. The primary advantage of ethnohistoric evidence is the details which are available in the writings of the chroniclers concerning the preparation and use of specific plants.

Iconographic evidence is also limited by the difficulties encountered in identification of the plants depicted in pre-Columbian Peruvian art. The morphological accuracy of these representations varies tremendously. Some Mochica vessels, for example, were apparently molded directly from the plants themselves, whereas the representations found on some of the later Chimu and Inca ceramics are more ambiguous and stylized. The chronological placement of iconographic evidence may also limit its utility. Unfortunately, such placement must frequently be made on the basis of typological similarities to poorly dated local and regional sequences. This lack of precise

temporal placement presents difficulties when attempting to deal with temporal units smaller than the established ceramic periods or with transitional periods.

While the depiction of a specific plant on pre-Columbian artifacts indicates a certain degree of familiarity with at least one individual plant, it does not directly indicate the significance of that plant in the subsistence system. The frequency with which a plant is depicted may indicate its importance within an artistic or ceremonial context, but it does not necessarily indicate that it is a significant subsistence crop. Likewise, iconographic representations may represent preferred or prestigious food plants and not those most generally consumed. Such a case could be made for the use and representation of maize and potatoes by the Inca (Murra 1960). The advantages of iconographic evidence are its durability and the association of certain plants with other iconographic elements. These associations can lead to a better understanding of the relationships between plants and the ideological systems responsible for their use.

The problem of the accurate identification of plants is not limited to ethnohistoric and iconographic evidence. The difficulties encountered in the identification of plant remains recovered from an archaeological context are primarily the result of the nature of archaeological evidence.

Materials recovered from an archaeological context undergo a series of selection processes. In the case of plant materials, this series of processes begins with the selection of a portion of the plant

to be utilized for a specific purpose - food, fiber, wood, etc. This portion may then undergo one or more modification processes before it is removed from the cultural system. The process by which it is physically removed from the cultural system is itself a selection process which defines the overall context from which the object, in modified or unmodified form, may be recovered. The selection processes do not cease here, however. The process of preservation also serves to select which materials will survive in a form in which they may be recovered by the archaeologist. And the archaeologist himself is responsible for the final selection processes. The manner in which he collects and analyzes these remains ultimately determines our understanding of the cultural processes represented in the archaeological record. We are limited not only by the uncontrollable processes of cultural selection and preservation, but also by the shortcomings and biases of the archaeologist.

The work of S. Pozorski (1976) in the Moche Valley is the only source of archaeological data directly relevant to the subject of this report. She has attempted, on the basis of excavated plant and animal remains from five sites to reconstruct the dietary percentages represented by the species recovered. This approach is based on the assumption that the relative presence of these remains in an archaeological deposit accurately indicates their relative significance within the cultural system responsible for that deposit. In the desert environment of the North Coast, the process of selection resulting from differential preservation is minimized. However, difficulties arise

as a result of the cultural selection processes responsible for the deposit. Grouping floral and faunal remains within a given excavation unit and ignoring natural strata obscures cultural selection processes and possible changes of cultural practices within the established periods of analysis.

The extent to which this combination can distort the interpretations derived from it can be seen by a comparison of the nine level descriptions for the sample from Padre Alban:

Level 1: Surface yellow-tan to gray fine silt and sand with some visible ash and shell.

Level 2: Light gray soft silt and sand with considerable ash and shell.

Level 3: Yellow to tan soft silt and sand with abundant plant remains, considerable shell and bone, and some rocks.

Level 4: Light gray soft silt and sand with considerable shell and bone, and some rocks.

Level 5: Yellow to tan soft silt and sand with abundant plant remains, considerable shell and bone, and some rocks. Virtually identical to Level 3.

Level 6: Light gray soft silt and sand with considerable ash and shell. Similar to Levels 2 and 4.

Level 7: Yellow to tan soft silt and sand with abundant plant remains, considerable shell and bone and some rocks. Similar to 3 and 5.

Level 8: Yellow to tan compact sand with small amounts of plant remains, shell and bone. Probably represents a mixture of sterile basal sand with the refuse-filled level above.

> Level 9: Very light gray to yellow loose sterile sand which closely resembles the modern beach.
> (Pozorski 1976:40-41) (underlining mine)

As may be seen from these descriptions, the cultural and/or natural processes which resulted in the excavated condition of the various levels are not equivalent on the basis of their differential contents and structure. The use of restricted sampling units from .1 to 4.2 cubic meters (Pozorski 1976:39) within single sites or contexts does not allow for variability within the deposits themselves. These variations could lead to an erroneous interpretation if, for example, the midden area excavated was adjacent to an undiscovered butchering station and had received a disproportionately high concentration of animal remains. In light of these considerations, I would hesitate to accept the dietary percentage figures as indicating more than these species' relative abundance in the excavated deposits. For these reasons, when reference is made to dietary percentage figures, they are intended only to indicate the relative abundance of specific plant remains for the sites excavated by Pozorski (1976).

In general outline and as a source of documented floral and faunal remains, Pozorski has provided an important step in our understanding of man's adaptation to the environment on the North Coast of Peru. Two additional references proved to be very useful in determining which cultigens might confidently be assigned to the Chimu period on the North Coast: "El Mundo Vegetal de los antiguos Peruanos" (Yacovleff and Herrera 1934-35), and The Ethnobotany of Pre-Columbian

Peru (Towle 1961). The most complete review of ethnohistorical evidence available is that of Yacovleff and Herrera, upon whom I have relied very heavily in this regard. Towle has produced the best synthesis of evidence relating to pre-Columbian ethnobotany in Peru published to date. And, as I mentioned above, Pozorski's study of prehistoric subsistence patterns is the only source available which incorporates large quantities of scientifically excavated materials.

Several authors have published lists of plants domesticated and/or used in ancient Peru. These lists, however, are generally concerned with the entire central Andean region and extremely long time periods. On the basis of the temporal and geographic limits relevant to this study, I compiled a composite list of plants from five major sources (Bennett and Bird 1964:15-17; Gillin 1947:23; Horkheimer 1973:97-100; Steward and Faron 1959:49-50; Towle 1961:142-143). The following list contains those plants for which sufficient ethnohistoric, iconographic, and/or archaeological evidence exists to illustrate their presence on the North Coast during the late prehistoric period (see Table 11).

Grains

Maize - Corn	(Zea mays)

Legumes

Mani - Peanut	(Arachis hypogaea)
Pacae	(Inga feuillei)
Pallar - Lima Bean	(Phaseolus lunatus)
Frijol - Common Bean	(Phaseolus vulgaris)

Algarroba	(Prosopis chilensis)

Fruits

Chirimoya	(Annona cherimolia)
Guanábana - Soursop	(Annona muricata)
Cansaboca	(Bunchosia armeniaca)
Zapallo - Squash	(Cucurbita maxima)
Calabaza - Squash	(Cucurbita moschata)
Caigua	(Cyclanthera pedata)
Pepino - Tree Tomato	(Cyphomandra sp.)
Lúcama	(Lucama bifera)
Palta - Avocado	(Persea americana)
Guava	(Psidium guajava)
Pepino	(Solanum muricatum)
Tomatillo - Wild Tomato	(Solanum peruvianum)

Roots and Tubers

Achira	(Canna edulis)
Camote - Sweet Potato	(Ipomoea batatas)
Yuca - Manioc	(Manihot esculenta)
Papa - Potato	(Solanum tuberosum)

Condiments

Ají - Chili Pepper	(Capsicum sp.)

Nuts

Nogal - Peruvian Walnut	(Juglans neotropica)

Containers

Calabazo - Gourd	(Lagenaria siceris)

Fiber Plants

Algodón - Cotton	(Gossypium barbadense)
Totora	(Scirpus totora)

In the following sections, the above plants are arranged alphabetically by genus into eight categories. In most cases, these categories indicate the part of the plant used or the purpose for which it was utilized.

Of the twenty-seven plants discussed below, three (chirimoya, pepino - S. muricatum, and yuca) are included for which no direct iconographic or archaeological evidence could be found indicating their use by the Chimu. Sufficient indirect evidence exists, however, to merit their inclusion. This evidence includes ethnohistoric accounts describing the presence and/or use of these plants on the North Coast, and/or archaeological evidence that they were present both before and following this period. This type of evidence is not conclusive, but it is highly suggestive and cannot be completely dismissed.

GRAINS

Zea mays L.

Maize was an important crop in the Andean region, but not to the extent that it served as a staple in Central America. Unfortunately, our understanding of the extent of its use is very limited. The ethnohistoric accounts indicate that much of the cultivated maize was consumed in fermented form as chicha. It has also been suggested that maize was eaten boiled, in the milk stage, and roasted or popped (Sauer 1950:494; Towle 1961:25). Maize bread or cakes have been reported by Safford (1917:14-15) and Wittmack (1880-87:329) as having been recovered from burials.

A recent article by Katz, Hediger, and Valleroy (1974) may provide some insight into the lesser role played by maize in Peru than in the Mesoamerican region. The cooking of maize in an alkaline solution, such as is the practice in Mesoamerica, has been shown to significantly alter the amino acid content of the maize which produces a

nutritionally higher quality food product. No evidence for alkaline processing of maize has been found among Andean groups. The nutritional dificiencies of untreated maize may account for the presumed smaller role played in the Andean region.

It is interesting to note, however, that maize played a very important role in the iconography of the North Coast peoples, and that it has been recovered in considerable quantities from archaeological sites. This evidence seems to indicate that maize may have played a more significant role in the diet of the coastal populations than has been previously assumed. The processing of maize into chicha involves several processes which certainly alter the biochemical constituents of the food product. Sprouting and long periods of boiling (Gillin 1947:46-48) would certainly affect the nutritional value of chicha. Unfortunately, no nutritional analyses have been made on chicha and, as a result, its food value is presently unknown. It is possible, however, that these processes may accomplish biochemical changes similar to those of alkaline cooking described by Katz, Hediger, and Valleroy (1974). This certainly suggests that nutritional analyses of prehistoric crops and processing procedures could shed important light on the pre-Columbian Andean diet.

A grindstone fragment which Pozorski (1976:121) associates with an increased emphasis on maize was found in the Early Intermediate levels at the Moche huacas. Topic (1977) has recovered several milling stones from kitchen areas within the small irregular agglutinated rooms (SIAR) composing the barrios of Chan Chan. Unfortunately, the

materials ground apparently were not found in association with the stones. Shimada (1978) has also recovered grinding stones from the late Early Intermediate site of Pampa Grande in the Lambayeque Valley. While they were directly associated with other food preparation items, the materials being ground apparently were not preserved. It is generally assumed, however, that these implements were used in grinding maize as they are by the modern inhabitants. Topic (1977) found several cases where looters in Chan Chan had apparently intentionally excavated to obtain a milling stone.

Pozorski also discerned a trend during the Late Intermediate and Late Horizons toward less reliance on maize as a staple. Her excavations indicate that the importance of maize decreased during this period with a concurrent increase in the importance of several fruits (1976:277). The percentage of plant diet comprised by maize ranged from 2.1 percent to 50.0 percent, with a mean of 15.5% for the twelve cuts made in five Late Intermediate Period and Late Horizon sites. These percentages compare with a range of from 32.5 percent to 99.4 percent with a mean of 54.2 percent for nine cuts made in two Early Intermediate Period and Middle Horizon sites. These figures seem to substantiate a decreased reliance on maize in the later periods.

It is not possible on the basis of such limited evidence to extrapolate the percentage of Chimu agriculture devoted to maize cultivation. The mean of 15.5 percent might be a good approximation, but its reliability would be suspect as it does not include any

consideration of surplus production for trade, tribute, or storage against crop failure.

LEGUMES

Arachis hypogea L.

Peanuts or maní have a wide distribution on the coast. They have also been recovered from Cupisnique (Whitaker and Bird 1949:6) to Inca (Towle 1961:43) period sites. The manner in which peanuts were used and the role which they played in prehistoric subsistence systems is virtually unknown. Iconographic evidence indicates that the peanut may have played some role in the ideological or religious system of the Mochica, but no such evidence has been found for the Chimu. Pozorski recovered peanut remains from four of the five Chimu sites investigated, but in no case did they exceed 1 percent of the plant diet represented in an excavation unit. Unfortunately, the available evidence is not sufficient to allow us to adequately determine the precise role of the peanut in the Chimu subsistence system.

Inga feuillei DC.

Pacae refers both to the tree and to its pods, which contain a fibrous sweet white edible pulp. The pulp is eaten fresh, and the black seeds and large pods are discarded. Pacae appears sometime around 2500 B.C. on the Central coast (MacNeish, Patterson, and Browman 1975:33). The pods, which are 20 or more centimeters long and about 2 centimeters wide, are excellently reproduced in Chimu ceramics. In addition, Pozorski recovered specimens from all five Chimu period sites she excavated, but in very limited quantities, less

than 1 percent for all excavation units.

Phaseolus lunatus L.

Lima beans or pallares have a long history on the North Coast. Bird recovered specimens from the lower levels of Incipient Agriculture in Huaca Prieta, and Towle reports them from the Inca levels at Pachacamac (Towle 1961). We have no evidence regarding the manner in which lima beans were actually consumed, but it is generally assumed to have been in a boiled form.

Pallares are common in the iconography of Mochica ceramics, appearing in many anthropomorphic and zoomorphic forms. Larco Hoyle (1943) has even suggested that they may have served as ideographic elements in a system of glyphic writing. No comparable evidence, however, has been recovered for the Chimu.

Lima beans were recovered from three of the five sites investigated by Pozorski, but only in very limited quantities.

Phaseolus vulgarus L.

The common bean, or frijol, first appears on the North Coast of Peru during the Cupisnique Period. According to Pozorski (1976: 200), the common bean served as an important staple during the Early Intermediate Period, but decreased in importance in the Late Intermediate Period. None the less, common beans were recovered in limited quantities from all five Chimu sites which she studied. In all of these sites, the frijol was more common than the lima bean, indicating that it probably played a more important role in the Chimu subsistence system. Like the lima bean, the frijol was probably

consumed in boiled form, but we lack direct archaeological evidence that this was the case.

Prosopis chilensis (Mol.) Stuntz

The algarroba tree produces sweetish edible pods from five to fifteen centimeters long. Towle (1961:56) states that there are historical references to the use of algarroba seeds as food for humans during the prehistoric period. Rostworowski (1975), as well as Yacovleff and Herrera (1934-35), cite several specific references to the use of algarroba as both a food and in the production of a variety of the drink chicha.

> The ordinances of the visitador Juan de Hoces (a Spanish government official) prohibited the use of any drink made from yuca, algarroba, and of (sprouted) maize under penalty for the violation of this order of being whipped in the public plaza and being shaved (Translation of Rostworowski 1975:331-332).

> Las ordenanzas del visitador Juan de Hoces prohibían el uso de cualquier bebida hecha, fuera de yuca, de algarrobo y la llamada de jora, so pena, para el que contravenía sus disposiciones de ser azotado en la plaza publica y de ser trasquilado (Rostworowski 1975:331-332).

> All of the trees that grow in these valleys of the rivers (of New Spain) are for the most part spiny, and produce a fruit that the Spanish call garroba because they have that flavor, and they formed a pod of beans. (Translation of Oviedo (SLVI) as cited by Yacovleff and Herrera 1934-35:291).

> Todos los árboles que nacen en aquestos valles de estos ríos (de la Nueva Castilla) son por la mayor parte espinosos, e producen una fructa que los españoles llaman garroba, porque tienen aquel sabor, e son de hechura de unas baynas de

> fesoles (Oviedo (SLVI) as cited by Yacovleff and Herrera 1934-35:291).
>
> All of this road in the plains is bordered on both sides by a wood with many fruits. On one hand they provide shade for the travelers and on the other provisions for those not carrying any food. Particularly, there are the garrobo trees which has fruit like our garrobas. They make a kind of bread (from it) with which they are sustained (Translation of De las Casas (253) as cited by Yacovleff and Herrera 1934-35:291).
>
> Todo este camino (en los llanos) por ambos a dos lados iba cercado de arboledas fructíferas puestas todas a manos, lo uno para que hiciesen sombra a los caminantes, y lo otro para provisión de los pobres que no llevasen qué comer. Y senaladamente los árboles eran de unos garrobos cuya fructa es como nuestros garrobas, de que hacen cierta manera de pan con que se suelen mantener... (De las Casas (253) as cited by Yacovleff and Herrera 1934-35:291).

All five of the Chimu period sites investigated contained the remains of algarroba in the form of seeds, with the exception of only Cerro la Virgen, for which no seed count is given (Pozorski 1976:424). Pozorski did not include algarroba as contributing to the plant diet of the prehistoric populations of the Moche Valley. Given the historical references and the prevalence of remains recovered from archaeological contexts, this possibility should be seriously considered.

FRUITS

Annona chirimolia Mill.

The chirimoya, a close relative of the guanábana, has been identified from several archaeological sites (Safford 1917:19; Towle 1961:38-39; West 1977). Bernabé Cobo, however, states that he

introduced the chirimoya into Peru from Guatemala in 1629:

> It has soft white flesh with a delicious bittersweet flavor. In the judgment of many, it is the best and most pleasant fruit of all those native to the Indies.
>
> It has been a few years since I gave the chirimoya to Peru. I first saw it in Guatemala City when I was traveling to Mexico in 1629. It seemed to me such a pleasant fruit which was not found in this country, so I sent here a good quantity of its seeds to an acquaintance to distribute them among his friends, which he did. In this way, when I returned from Mexico after 13 years, I discovered that many of these trees were grown and carried fruit. But they were so expensive that they sold for from eight to twelve reales for each chirimoya. But they are already becoming more abundant because many have been planted and more are planted each day (Translation of Cobo 1891,2 (6):18).
>
> Tiene la carne blanca y suavísima, con un agridulce apetitoso, de suerte que, a juicio de muchos, es la fruta mejor y mas regalada de todos las naturales de Indias.
>
> Ha pocos años que se da en este reino del Perú la Chirimoya, la cual, donde yo primero la ví fue en la ciudad de Guatimala el año de 1629, caminando para México; y parecióme fruta tan regalada, que sentí careciese della este reino; y así, envié desde allí una buena cantidad de sus pepitas a un conocido, para que las repartiese entre los amigos, como lo hizo. De manera que, cuando volví yo de México a cabo de trece años, halle que ya habían nacido muchos destos arboles y llevaban fruto (I); pero era tan caro, que se vendían las chirimoyas a ocho y a doce reales cada una; pero ya se dan con mas abundancia por las muchas que se han plantado y plantan cada dia (Cobo 1891,2(6):18).

If the plant remains recovered from archaeological contexts have been

correctly identified, and there is no reason to believe otherwise, then Cobo could not have introduced the chirimoya to Peru.

No chirimoya remains were recovered from Pozorski's excavations in the Moche Valley. It is interesting to note that while both the chirimoya and guanábana have been recovered from Early Intermediate Period sites in the Viru Valley, only the guanábana seems to have been adopted in the Moche Valley, and there only much later.

Annona muricata L.

The soursop, or guanábana, is a large spiny ovoid fruit which is cultivated along the entire coast of Peru. These fruits are reproduced in Chimu ceramics, and their remains are first recovered during the Late Intermediate Period in the Moche Valley (Pozorski 1976:201). West (1977; n.d.), however, reports that they have been recovered from Puerto Moorin phase sites (early Early Intermediate) in the Viru Valley, 45 kilometers to the south. Due to the recovery of large numbers of seeds from the five Chimu sites which she excavated, Pozorski has proposed that the newly introduced guanábana became very popular during this period and, with another fruit, the lúcuma, comprised the staple of the Chimu plant diet. Her studies indicate that guanabana comprised between 3.0 percent and 45.4 percent of the plant diet represented in the excavation units of the Chimu sites.

Bunchosia armeniaca (Cav.) Rich. apud Juss.

The cansaboca is a small fruit approximately 2.5 centimeters

long and 2 centimeters in diameter. The seeds of this fruit were recovered from the pre-ceramic levels of Huaca Prieta (Whitaker and Bird 1949:3) and are represented on Mochica and Chimu ceramics (Towle 1961:61, plate XII). The cansaboca was recovered from four of the Chimu sites studied by Pozorski (1976), but in very limited quantities.

Cucurbita maxima Duch.

Cucurbita moschata Duch.

Squash has a long history on the coast of Peru. The calabaza, C. moschata, occurs in the pre-ceramic levels of Huaca Prieta (Whitaker and Bird 1949:14) and as early as 3,000 B.C. in the Ancon-Chillon region (MacNeish, Patterson, and Browman 1975:29). Both the zapallo, C. maxima, and the calabaza are accurately reproduced in Mochica and Chimu ceramics, indicating their continued presence in these later periods. Squash seeds, identified only as Cucurbita sp., were recovered from all five of the Chimu sites excavated by Pozorski (1976:423, 437).

The importance of squash varied greatly through time and space on the North Coast. Pozorski (1976:200) has determined that, like maize, the use of squash seems to have declined during the Late Intermediate.

West and Whitaker (n.d.) have found an interesting temporal and spatial distribution of C. maxima and C. moschata on the Peruvian coast. Analysis of the remains from ten sites in the Viru Valley indicates that C. maxima occurs in sites dating to no later than the

transition between the Puerto Moorin and Gallinazo phases of the Early Intermediate Period, while C. moschata occurs no earlier than this transition.

This distribution is most interesting in light of the fact that the remains of C. maxima have not been recovered, outside of the Viru Valley, in deposits dating earlier than about 600 A.D. (West and Whitaker n.d.). At about this same time, C. maxima is depicted in Mochica ceramics. C. moschata, on the other hand, has been found as early as about 3000 B.C., as I mentioned above. The authors are unable to offer an explanation for the observed temporal and spatial variations found in the distribution of these species.

A similar analysis of the Cucurbit remains recovered by Pozorski (1976) might help to explain the interesting temporal and spatial distributions of this important cultigen.

On the basis of ethnographic evidence, Sauer has described the ways in which the squash has been utilized in Central and South America:

> Immature, they are in their season the most important green vegetable. Ripe, they are boiled and especially roasted as an important source of starchy and sugary food. Their excellent keeping qualities make storage possible for months, and they are often cut in strips and dried in the sun or over coals. The seeds are largely used roasted, and in some cases, are even more prized than the flesh (Sauer 1950:505).

This description is based on an ethnographic sample which extends far outside of the area of concern here, but it does indicate a range of

utilization techniques which has been used in the preparation of squash.

Cyclanthera pedata (L.) Schrad.

Larco Hoyle (1946:150) reported finding representations of the caigua in Cupisnique ceramics. Pozorski (1976:406, 423, 430, 435) recovered four seeds of this cucumber-like fruit from three of the sites she investigated. According to Sauer (1950:505-506), they are eaten both raw and cooked.

Cyphomandra sp.

The tree tomato, or pepino, is a rather small smooth-skinned fruit. The term pepino is also applied to the Solanum muricatum, a somewhat larger fruit which is more ovoid than the pointed, egg-shaped tree tomato. Tree tomatoes have been identified on Chimu ceramics (Safford 1917:fig. 5; Kauffmann Doig 1964:109-110). No archaeological remains of this fruit have yet been identified.

Lucuma bifera Mol.

The lúcuma is a medium sized green tree fruit with a bright orange to yellow, dry, mealy pulp. The earliest examples of this fruit on the North Coast are found in the pre-ceramic level at Huaca Prieta (Whitaker and Bird 1949:3) and at Alto Salaverry (Pozorski 1976:85). Pozorski's excavations indicate that the lúcuma played a relatively important role throughout much of the prehistoric period in the Moche Valley. This is particularly true for the Late Intermediate, when it and guanábana were the most common food plant remains recovered (Pozorski 1976:159).

The overwhelming prevalence of lúcuma and guanábana remains from excavations at five Chimu sites has led Pozorski to postulate a major shift in subsistence patterns. Between the Early Intermediate/ Middle Horizon and the Late Intermediate, she proposes that a major shift away from crop cultigens occurred with a concurrent rise in the importance of fruits, particularly the lúcuma and guanábana (Pozorski 1976:159).

Persea americana Mill.

The avocado, or palta, is first found on the North Coast at Gramalote, an Initial Period site in the Moche Valley (Pozorski:1976). It has also been recovered in considerable quantities from the Moche V site of Pampa Grande in the Lambayeque Valley (Shimada and Shimada n.d.). Pozorski found the remains of avocados in all five Chimu period sites, but only in small quantities. The perishability of this fruit probably served to limit its utility within the Chimu redistribution system proposed by Pozorski (1976). Its importance in the Chimu subsistence system is not well documented at the present time.

Psidium guajava L.

The guava, or guayaba, has been recovered from Early Intermediate Period sites in the Viru and Moche Valleys (Towle 1952: 355; Pozorski 1976:125) and by Pozorski (1976:172) from a single Chimu site in the Moche Valley. Pozorski recovered only a single fruit of this species from her excavations at five Chimu sites, which may indicate that the guava played only a minor role in the Chimu

subsistence system.

Solanum muricatum Ait.

As I discussed above, both this plant and some species of Cyphomandra are referred to as pepino. The pepino is well represented on Mochica ceramics (Larco Hoyle 1938-39(1):78) and is discussed by the early chroniclers as having been present on the North Coast at the time of the Spanish conquest:

> The best pepinos are found in the valleys of the coast of Peru. They are especially famous from the Trujillo, Ica, and Chincha Valleys where the soil is warm and sandy (Translation of Cobo 1890, 1(4):382).
>
> Dánse los mejores pepinos en los valles desta costa del Perú; señaladamente tienen fama los de los valles de Trujillo, Ica, Chincha, porque quieren tierra caliente y arenisea (Cobo 1890, 1(4):382).

The remains of this plant have not been recovered from an archaeological context. This is probably the result of the fact that the fruit completely lacks or contains only vestigial seeds which are not likely to be preserved in an archaeological context. It is very likely, however, that the pepino was cultivated during the late prehistoric period on the North Coast.

Solanum peruvianum L.

The wild tomato, or tomatillo, was recovered by Pozorski (1976:173-174, 191) from two Chimu sites. They account for less than 1 percent of the plant diet for each of the three cuts from which their remains were recovered. Pozorski considers that they were not cultigens, but represent wild foods gathered to supplement the regular

diet. Their presence in only two satellite communities in such small proportions would indicate that they probably did not account for any significant part of Chimu subsistence even if they were cultivated.

ROOTS AND TUBERS

Canna edulis Ker-Gawl

Achira tubers were not recovered from any of the excavations carried out by Pozorski (1976). However, Yacovleff and Herrera (1938-39:311, Fig. 30b) illustrate a ceramic vessel which they identify as a Chimu representation of achira tubers. The absence of this plant from the archaeological record is not entirely unexpected. As with many roots and tubers which are consumed in their entirety, little, if any, physical remains survive to become incorporated into archaeological deposits. A coprolite analysis might be a more useful approach to identifying the importance of plants such as this which are wholely consumed. On the basis of only a single vessel recovered from an unspecified site, it is not possible to determine the relative importance of this crop.

Ipomoea batatas (L.) Poir. ex lam.

The remains of the sweet potato, or camote, were recovered from only a single Chimu site in the Moche Valley during the excavations conducted by Pozorski (1976:181). Sweet potatoes have, however, been documented as occurring in a number of earlier sites (Towle 1961: 79; West 1977:7), as well as being excellently reproduced in Mochica ceramics (Yacovleff and Herrera 1934-35:274). From this limited data, it appears that the camote may have served a minor role in the Chimu

subsistence system.

Manihot esculenta Crantz

The elongate tubers of this plant have been described as a staple food in prehistoric Peru (Towle 1961:61). Manioc, or yuca, is represented on ceramics as early as the Cupisnique Period (Larco Hoyle 1941:42, 1946:150), and the actual plant remains have been recovered from Puerto Moorin Period sites in the Viru Valley (West 1977:7) and by Eling (personal communication) near the site of Pacatnamu in the Jequetepeque Valley. Representations of yuca tubers are found on Mochica ceramics, and the plant is described by chroniclers as having been used by the coastal populations (Yacovleff and Herrera 1934-35:272-273). Gillin's (1947:49, 57) ethnographic study of a traditional coastal community in the Moche Valley also points to the continuing importance of manioc.

While no remains of manioc were recovered from Pozorski's excavations, the overwhelming evidence indicating its importance before and after the Chimu period leads me to postulate that this lack of recovered material may be only an accident of preservation and/or sampling.

Solanum tuberosum

Iconographic representations of potatoes, or papas, on Chimu ceramics (Salaman 1949:Figs. 8-12) and Cieza de Leon's description of potatoes on the coast (de Onis 1959:317) indicate that they probably played some role in the Chimu subsistence system. Salaman (1949:34, 37), however, is skeptical that potatoes were ever cultivated on the

coast due to climatic conditions not condusive to their growth.

Actual remains of potatoes, frequently in the form of chuño, potatoes dried by freezing, have been recovered from archaeological sites on the Central and South Coasts, but have not as yet been found on the North Coast. Salaman (1949:35) proposes that potatoes, both as tubers and chuño, were an important item in the trade between the highlands and the coast.

It is probably appropriate to include the potato in the subsistence system of the Chimu. However, given the environmental limitations imposed on its cultivation in the lower valleys, it will not be considered a part of the agricultural system relevant to this study.

CONDIMENTS

Capsicum sp.

Capsicum annuum L.

Capsicum frutescens L.

The chili pepper, or ají, first appears in the archaeological record of Peru about 2500 B.C. (Pickersgill 1969:55), and continues as an important cultigen through the Late Horizon. Chili peppers were recovered in small, but consistent amounts from the Chimu sites excavated by Pozorski (1976:159, 165, 171, 181, 189).

NUTS

Juglans neotropica Diels.

The Peruvian black walnut, or nogal, grows in the valleys of both the eastern and western Andean slopes in comparatively dry

conditions between 1500 and 2100 meters. It can also be cultivated on the coast under irrigation (Seibert 1950). The remains of this plant, presumably the shells, were recovered from three levels at a single Chimu site during Pozorski's (1976:424) investigations in the Moche Valley.

The early chroniclers also mentioned the nogal, but did not make specific reference to the North Coast. The walnut, since it can be cultivated under irrigation on the coast, certainly could have contributed to the subsistence system of the Chimu. The evidence available at present does not indicate that it ever did, however.

CONTAINERS

Lagenaria siceria (Mol) Standl.

The gourd, or calabazo, has been recovered from the preceramic levels at Huaca Prieta (Whitaker and Bird 1949), as well as from a more or less continuous series of other North Coast sites extending into the Late Intermediate and Late Horizon (Pozorski 1976; Towle 1952). The Spanish chroniclers noted that the immature gourd was not eaten in the New World as it was in the Old (Sauer 1950:506). Its continuous presence in the archaeological record, even after the introduction of ceramics, indicates that it still played some role in the prehistoric societies and continued to be cultivated.

FIBER PLANTS

Gossypium barbadense L.

Cotton, or algodón, has been recovered from numerous preceramic coastal middens and continues as an important cultigen into

the Late Horizon. The first appearance of cotton occurred approximately 2500 B.C. on the Central and North Coasts of Peru (Stephens and Moseley 1974:110). Pozorski (1976:184), in her study of the Moche Valley, has proposed that the site of Cerro la Virgen served as a satellite community to Chan Chan during the Chimu period and that its primary role was the cultivation of state cotton fields. This proposal was based upon the very large number of unprocessed cotton remains recovered from the site, and upon its immediate proximity to large expanses of agricultural fields.

The importance of cotton as a cultigen and fiber source throughout Peruvian prehistory, but particularly in the later periods, should not be underestimated (Gayton 1961; Vreeland 1977). Considerable areas must have been planted in cotton in order to supply the large fiber requirements of the Chimu State.

Scripus tatora Kunth

The totora reed is the raw material from which caballitos, or reed boats are made. The presence of deep water fish remains in archaeological sites, as well as iconographic representations, points to the importance of the caballitos and the larger reed balsas to the Chimu economy. Even a moderately sized fishing fleet composed of caballitos and balsas would require large amounts of totora reeds since they become waterlogged after about one month (Pozorski 1976: 211-212). Perhaps the largest single use of totora, however, was as a construction material. In the form of large woven mats, totora was used to form the walls of dwellings, a practice still seen in some

barrios and squatter settlements found on the coast. In addition, totora reeds probably served as mattresses for much of the coastal population.

Discussion

Pozorski (1976) has proposed that Chimu subsistence was based largely on a redistributive system which served to supply necessary food stuffs to productively specialized communities. She proposes that two fruits, lúcuma and guanábana, dominated the Chimu plant diet, while maize, beans, and squash occurred in more limited amounts (Pozorski 1976:200-202). This reconstruction differs significantly from the more traditional view with its emphasis on maize and beans (Kosok 1965:95).

Pozorski's reconstruction is based on the following assumption:

> This analysis of subsistence data from controlled samples was based on the assumption that plant and animal remains within an excavated volume occur in frequencies which are indicative of their importance to the people at the site (Pozorski 1976:64).

Such an assumption may not be accurate, however. The frequencies of plant remains within a deposit need not be explained solely by recourse to cultural processes such as dietary preferences.

As Pozorski (1976:68) has pointed out, not all plant remains can be considered as equivalent. Roots and tubers, for example, have no seeds or cobs which may be recovered from archaeological sites. Plants and plant parts are differentially subject to the biological,

chemical, and physical processes of decay. Preservational factors play a significant role in determining what plant remains will be recovered from an archaeological deposit. However, in environments such as are found on the coast of Peru, where preservation is generally good, cultural and natural depositional factors play a more important role in determining the nature of an archaeological deposit. By evaluating the plant remains recovered by Pozorski (1976) in terms of the selection processes described earlier in this chapter, it is possible to present an alternative reconstruction of Chimu subsistence.

There can be little doubt that the importance of the lúcuma and guanábana increased during the Chimu period. At no previous time did these fruits appear in such high densities in domestic refuse in the Moche Valley. However, increased density is not sufficient basis upon which to postulate that they were of primary importance within the Chimu plant diet.

Given a redistributive system such as that described by Pozorski, the form in which agricultural products are distributed is of the utmost importance to a reconstruction of subsistence patterns from archaeological remains. Prior to the development of refrigeration and canning technology, fruits were transported fresh or dryed. In a system which redistributes fresh fruits, it is logical to assume that all sites will contain seeds in proportions relative to the amount of fruit available to the site.

The redistribution of dried fruits may not produce similar

relationships, however. Processing during the drying procedure may remove the more readily preserved seeds. Such a procedure would significantly alter the relationships assumed by Pozorski in her reconstruction of Chimu subsistence.

Fruits, even those found within tropical climates, tend to be seasonal. Irrigation and the cultivation of vertically stratified environments may mitigate the effects of seasonality. The extent to which the Chimu exercised these options in regard to fruits and many other products is incompletely understood at the present time. However, it is not necessary to postulate a large-scale controlled redistribution system to explain the quantity and extent of lúcuma and guanábana remains recovered from Chimu sites. It is more likely that fruit trees were grown near homes and fields much as they are today. Well tended fruit trees can yield prodigious quantities of fruit on a seasonal basis. The remains of such large quantities of fruit, when accumulated in a refuse deposit might be interpreted as evidence of a dietary staple. It is, however, extremely unlikely that the nutritional value of lúcuma and guanábana is such that the dietary percentages postulated by Pozorski would provide an adequate diet.

The physical remains of maize and beans vary significantly from those of lúcuma and guanábana. The inedible cobs and pods would seem more likely to be recovered from refuse deposits than would be edible kernels and beans. In the case of beans and, to a lesser extent maize, however, the pods and cobs need not be redistributed

with the foodstuffs, as in the case of fresh fruit.

Maize may be eaten green or after having ripened and dried. If it is eaten when green, then it is likely that the inedible cobs would be redistributed to the non-agricultural sites within the system along with the primary foodstuff. It is then logical to expect that the inedible plant parts recovered from non-producing sites will reflect the relative proportion of maize available to them. However, when dry, both maize and beans may be subjected to processing (shelling) prior to redistribution. Under these conditions, certain sites, those devoted to agricultural production, would be expected to have a very high occurrence of inedible cobs and pods relative to non-agricultural sites. In addition, maize and beans, when dry, are amenable to long-term storage and are most efficiently stored and transported in shelled form. Shelled corn and beans have been recovered from storage areas within the Moche V site of Pampa Grande in the Lambayeque Valley:

> Discoveries of large quantities of carbonized corn kernels and beans in burnt formal storage facilities (Unit 32 in Sector H and Unit 51 in Sector D; cf. Anders 1975) at Pampa Grande attest to the importance of storable crops and a high level concern with long-term usage and distribution (Shimada and Shimada n.d.).

Under these circumstances, cobs and pods should compose a higher percentage of maize and bean remains recovered from agricultural sites than from non-agricultural sites. In the non-agricultural sites, these plants should be represented more often by kernels and beans, the actual redistributed food products.

According to data presented by Pozorski, this is the case. Bean pods and corn cobs tend to be concentrated in the agricultural sites. The overwhelming presence of maize kernels in these agricultural sites may be explained as the result of losses during shelling and processing. Their relative paucity at non-agricultural sites is in keeping with the increased value of the processed food product (see Table 9).

With the exception of a single specimen recovered from the site of Cerro la Virgen, an entire class of cultigens is missing from Pozorski's excavations. Roots and tubers are conspicuous by their absence. Yuca, camote, and achira have all been recovered from archaeological sites on the North Coast and are represented on Mochica ceramics. In addition, they are mentioned by the chroniclers as having been cultivated on the coast at the time of the conquest (see Table 11).

Strong and Evans (1952:83-84) and Kosok (1965:108, fig. 28b) suggest that ceramic graters found on the North Coast may have been used to grate yuca. If this is the case, which seems likely, the distribution of graters may give some indication of the importance of yuca in the prehistoric diet.

Further conjectural evidence for the importance of yuca can be found by reference to the limited number of high starch food products available to prehistoric coastal populations. The potato, the most common highland Andean starch, will not grow in the lower coastal valleys. Yuca, also a high starch root crop, is a logical

Table 9. Comparison of plant remains of maize (Zea mays) and beans (Phaseolus vulgarus) from five Chimu sites in the Moche Valley, Peru[1].

AGRICULTURAL SITES	VOLUME EXCAVATED (m^3)	MAIZE				BEANS			
		KERNELS		COBS		BEANS		PODS	
		NO.	/VOLUME[2]	NO.	/VOLUME[2]	NO.	/VOLUME[2]	NO.	/VOLUME[2]
Co. la Virgen									
cut 1	1.3	466	358.5	77	59.2	0	0	281	216.0
Choroval									
cut 1	1.6	761	475.6	382	238.7	23	14.4	0	0
cut 2	1.4	119	85.0	74	52.8	8	5.7	0	0
NON-AGRICULTURAL SITES									
Chan Chan SIAR[3]									
cut 1	1.4	207	147.8	45	32.1	36	25.7	1	0.7
cut 2	2.2	66	30.0	19	8.6	7	3.1	0	0
cut 3	1.0	3	3.0	0	0	0	0	0	0
cut 4	1.3	1	0.8	4	3.1	0	0	0	0
Chan Chan Rivero									
cut 1	0.7	20	28.5	0	0	5	7.1	0	0
Caracoles									
cut 1	0.3	0	0	5	16.6	0	0	0	0
cut 2	0.5	16	32.0	20	40.0	1	2.0	0	0
cut 3	0.7	11	15.7	41	58.6	1	1.4	0	0
cut 4	0.4	18	45.0	28	70.0	2	5.0	0	0

(1) Data from Appendix 1. Prehistoric Subsistence Patterns and Site Economics in the Moche Valley, Peru (Pozorski 1976).
(2) Plant remains divided by the volume of the excavation unit to compensate for differences in the size of the cuts.
(3) SIAR, Small Irregular Agglutinated Rooms.

alternative.

This evidence suggests that roots and tubers played an important role on the coast immediately before and after the Chimu period. Two explanations can be given to account for the absence of root crops in Pozorski's excavations. The first is that the use of roots and tubers declined during the Chimu period and was revived shortly before the Spanish conquest. The second, more likely alternative is that their absence may be the result of sampling and/or preservational factors.

Several natural and cultural processes may preclude the incorporation of roots and tubers into refuse deposits. Due to the starchy nature of these crops, their preservation will occur only under the most ideal conditions. In addition, cultural selection processes may preclude the occurrence of unmodified root crops in refuse deposits. In the case of yuca which has been suggested as a dietary staple of the prehistoric coastal populations (Towle 1961:61), the tubers may be peeled and the central fibrous core removed prior to consumption. It is the peels and fibrous cores which are most likely to be recovered from domestic refuse deposits such as those excavated by Pozorski (1976). The species identification from these remains, however, would probably require a botanical specialist.

Other processes such as the production of chicha, which may involve sprouting (maize), grinding (maize, algarroba), or grating (yuca), can sufficiently modify the plant remains so that identification cannot be made without the aid of microscopic and/or chemical

analysis.

The occurrence of plant remains in refuse deposits can also be significantly affected by the recycling of refuse as feed for domestic animals such as guinea pigs, ducks, llamas, and dogs. Shimada and Shimada (n.d.) feel that this practice affected the floral remains recovered from the site of Pampa Grande in the Lambayeque Valley. In his excavations of the SIAR at Chan Chan, Topic (1977) noted the frequent occurrence of cuy (guinea pig), bird (duck ?) and llama dung in kitchen areas. An analysis of the various animal dung fragments recovered from these areas would substantiate whether or not refuse was recycled as animal food. The association of live domestic animals, as evidenced by primary deposits of animal dung, within or adjacent to food preparation areas suggests that this was the case.

Under these circumstances, it is likely that only those plant (and animal) remains which could not be consumed by guinea pigs, ducks, llamas, or dogs are likely to be preserved in refuse deposits. Lúcuma and guanábana apparently fall into that category. The recycling of refuse may then partially account for the relative preponderance of lúcuma and guanábana remains recovered by Pozorski. Plant remains recovered from refuse deposits may be as much a function of the practices of animal husbandry as of the importance of various plants to the groups responsible for the deposit.

Ethnohistoric accounts directly relating the importance of various food crops are sadly lacking. Indirect references such as

that cited below and those cited in reference to the use of algarroba give some indication of which plants were thought to be of sufficient importance to be specifically mentioned:

> ...We don't have lands to sow nor can we support ourselves but by trading for cotton, maize, beans and other things that we need (Translation of (AGI-Justicia 456, fol. 1922v) as cited in Rostworowski 1975:318).
>
> ... (no) tenemos tierras en que senbrar, ni nos podemos sustentar sino es con el rescate por algodón y mayz e fregoles y otras cossas de que tenemos necesidad (AGI-Justicia 456, fol. 1922v as cited in Rostworowski 1975:318).

In addition to the archaeological and ethnohistoric evidence discussed above, ethnographic studies can also provide evidence useful for the reconstruction of late prehistoric crops and diet. Ethnographic works such as Gillin's (1947) study of Moche provide important data on dietary practices in traditional coastal communities. The use of analogy, even in a highly traditional community, however, offers a number of difficulties.

The Peruvian coastal population underwent two invasions by outside groups: the Incas, and the Spanish. Under these circumstances, changes in dietary patterns might be expected to result from the introduction of new food products, the disruption and reordering of the redistribution systems and/or forced changes as in the case of chicha, discussed in reference to algarroba. The Inca most likely did not introduce any significant new cultigens into the lower valley, nor is there evidence that they imposed dietary changes. However, the

economic and social reorganization which occurred following the collapse of the Chimu Empire may have altered coastal dietary patterns. The Spanish not only disrupted and reorganized the social and economic systems and imposed dietary changes, but also introduced a number of plants and animals which significantly altered the dietary patterns on the coast. The dietary evidence presented by Gillin well illustrates these changes.

By dividing the food items discussed by Gillin (1947:58-59) into five different categories, it is easier to see the influence of food products introduced after the Spanish conquest. I have regrouped a number of specific menu items into larger categories and have eliminated such items as soups in order to facilitate comparisons. For example, all wheat products (bread, bisquits, cracked wheat, noodles, etc.) have been included as wheat under the general category of grain products. The five major categories used for this comparison are: beverages (including both plant and animal products), animal protein, grains, vegetables, and fruits (see Table 10).

There are several difficulties inherent in the use of these data to reconstruct prehistoric dietary patterns. Some refer directly to the data itself and have been discussed by Gillin (1947:55-56), while others relate to aspects of culture change such as those discussed above.

Summarized below are several of the notes and cautions presented by Gillin in regard to the use of these data. With regard to the validity of the data, he notes that none of the specific menu

Table 10 .[1] Summary of Moche Food Products.

Food Products[2]	# Items Reported	% Items within Category	% Indigenous Items within Category	% Total Items
Beverages				18.95
*tea	144	35.20		
milk	93	22.74		
chocolate	60	14.67		
coffee	51	12.47		
*water	40	9.78		
barley water	13	3.18		
*chicha	4	.98		
lemonade	4	.98		
	409	100.00	45.96	
Animal Protein				21.64
meat[3]	322	68.95		
*fish	96	20.56		
eggs	25	5.35		
dairy products	20	4.28		
butter	(18)			
cheese	(2)			
poultry-chicken	2	.43		
	467	100.00	20.56	
Grains				36.56
rice	433	54.88		
wheat	333	42.21		
*maize	19	2.41		
oats	4	.50		
	789	100.00	2.41	

Table 10 . Summary of Moche Food Products. (Continued)

Food Products[2]	# Items Reported	% Items within Category	% Indigenous Items within Category	% Total Items
Vegetables				20.76
*yuca	125	27.90		
vetches	55	12.28		
*kidney beans	47	10.49		
chickpeas	43	9.60		
*squash	35	7.81		
greens	27	6.03		
*common beans	17	3.79		
*olluco (highlands)	17	3.79		
lentils	17	3.79		
*camote	15	3.35		
onion	12	2.68		
*potatoes (highlands)	9	2.01		
*peanuts	9	2.01		
cabbage	8	1.79		
carrots	7	1.56		
*caigua	2	.45		
green beans	2	.45		
lettuce	1	.22		
	448	100.00	61.60	
Fruit				2.09
banana	17	37.78		
olive	10	22.22		
orange	10	22.22		
*chirimoya	3	6.67		
unspecified	3	6.67		
*granadilla	1	2.22		
watermelon	1	2.22		
	45	100.00	8.89	
TOTALS	2158			100.00

1 Adapted from Gillin (1947:58-59)
2 Items marked with an asterisk (*) indicate indigenous products.
3 All meat items reported in this study were from non-indigenous animals (i.e., beef, mutton, goat, or pork).

items reported were checked, but that certain items such as ají, salt, black pepper, and sugar, which were frequently not reported, were found to be common items in the Moche diet upon subsequent investigation. The manner in which the sample data was collected did not follow statistical sampling procedures and, hence, does not allow significant statistical manipulation. Also, the fact that the data was collected over a period of only three days in a single month (July, 1944) would significantly affect the presence of seasonally available food products. Perhaps the most important comment made by Gillin in this regard is in reference to the informant's from whom the data was gathered. The informants used in this analysis consisted of eighty-three school children ranging in age from eight to sixteen years. Gillin notes that:

> Although it is not customary for children to drink chicha for all thirst-quenching purposes as do adults, checking showed that a good many children had consumed chicha during the period of survey, but had omitted to include it in their essays because the hygiene lectures by the teachers had taught them that chicha drinking is considered officially undesirable (Gillin 1947:55).

Similar reasoning might indicate that certain food items such as milk are likely to be over represented.

The extent to which non-indigenous food items have been incorporated into the modern Moche diet makes a complete reconstruction of prehistoric dietary patterns on this basis alone impossible. It is possible, however, to discern trends which may be the result of traditional (pre-Columbian) dietary practices.

The category of beverages, as was noted above, may be seriously biased due to the age structure of the sample of informants. Chicha plays a far more significant role in Moche than is indicated by the figure represented in this analysis:

> The consumption of chicha according to data, seems to average about 2 l. per day per adult (over 18 years of age) for its "normal" or thirst-quenching properties, as an accompaniment of meals, etc., with an additional liter per day per adult as a conservative estimate for chicha consumed because of its festive properties. These are only estimates, based on relatively small samples of families, but seem to be on the conservative side, if anything; for when the Mocheros become festive, the amount of chicha consumed is prodigious (Gillin 1947:46).

This evidence seems to indicate that, for adults at least, the indigenous chicha is the most important beverage in Moche. Even among the children surveyed, an indigenous beverage, tea, made from yerba luiza, is listed as having been consumed more often than any of the non-indigenous beverages.

Sources of animal protein are dominated by non-indigenous animals (cattle, sheep, goats, and pigs). These animals provide almost 80 percent of the items found in this category. All of the meat products (68.95% of the animal protein consumed) come from animals not found in the pre-Columbian New World. Undoubtedly, some other sources of meat, probably llama, cuy, and duck, were used during the late prehistoric period. Fish, which composes over 20 percent of the animal protein may have played a more significant role during the prehistoric period. The remaining approximately

10 percent of the items included in this category (eggs - presumably chicken, dairy products, and chicken) were not available to the prehistoric inhabitants of coastal Peru. Archaeological evidence, in the form of ceramic representations (Larco Hoyle:1938-39) and excavated remains (Shimada and Shimada n.d.), indicate that the domesticated duck was utilized on the North Coast until at least the late Early Intermediate.

Of all the categories discussed in this analysis, none show the effect of the post-conquest introduction of food products to the extent apparent in the grain category. Over 97 percent of the grains eaten in Moche consist of the non-indigenous plants, rice (54.88 percent) and wheat (42.21 percent). Rice appears far more often than any other single food item in any category and serves as a basic source of starch in the Moche diet. Wheat is eaten in more forms than any other plant product in the Moche diet. This diversity may help to account for its high rate of consumption.

Maize comprised only 2.41 percent of the grain eaten during this study. The importance of maize as a food product should not, however, be underestimated on the basis of this evidence. In reference to the uses of maize, Gillin notes that:

> Maize grown in the countryside is used principally for roasting ears (choclos) and for making chicha. Certainly, the latter use absorbs by far the major part of the maize consumed in the community (Gillin 1947:46).

Just as the use of grains illustrates the strong influence of

introduced plant products, the use of vegetables shows the influence of the more traditional dietary practices. Over 61 percent of the vegetables described in Gillin's study are indigenous to Peru. This figure includes two highland plants (potatoes and olluco) probably never grown on the coast. Yuca was reported more than twice as often as any other vegetable and comprises almost 28 percent of the vegetable diet described in this study. Prior to the introduction of rice and wheat, yuca may well have served as the primary starch item in the coastal diet. Beans, both indigenous (kidney beans and common beans) and introduced (chick peas), comprise almost 24 percent of the Moche vegetable diet. It seems likely that such an important source of vegetable protein probably played an equally important role during the late prehistoric period. Squash (7.81 percent of the Moche vegetable diet) was very likely at least as important as an additional source of carbohydrates prior to the Spanish conquest as it is now.

Fruits comprise only 2.09 percent of all the food items in this analysis. Of those fruits reported, at least 84 percent are not indigenous to the New World. This figure does not include three fruits listed as unspecified which were included as indigenous for the sake of argument. Gillin gives a possible explanation for the small role played by fruits in the Moche diet:

> The slight place taken by fruit in the diet is in part explained by the fact that the survey took place in July, early winter, at which season little local fruit is available (Gillin 1947:57).

The same reason may account for the complete absence of lúcuma and guanábana, two fruits believed by Pozorski (1976) to have been Chimu staples.

In light of the evidence discussed above, and despite evidence to the contrary offered by Pozorski's excavations, I would include maize, beans, yuca, and squash as primary cultigens during the Chimu period. Yuca may well have served as one of three or four staple food crops during this period. The inclusion of yuca as an important crop is based on the evidence outlined above: its known importance before and after the period, and the preservational and/or recovery factors which may be used to explain the results of Pozorski's excavations.

This discussion of the relative importance of lúcuma, guanábana, maize, beans, yuca, and squash in the Chimu diet is in substantial disagreement with the ideas proposed by Pozorski (1976). I have offered an alternative interpretation which must be tested against additional data, but which I feel adequately explains the existing evidence.

Summary

In this chapter I have discussed some twenty-seven different plants which I believe were probably cultivated in the lower coastal valleys during the Chimu period. Of these, twenty-four are food plants, and three are industrial plants. Given the paucity of excavated subsistence data, it is not possible to exactly determine the importance of each cultigen.

I am in agreement with the traditional view that maize and beans (Phaseolus sp.) constituted the most important coastal food crops. In addition, yuca probably also played an important role, with the fruits lúcuma and guanábana playing a significant, if seasonal, role as well. Squashes probably also served as an important source of carbohydrates during this period. Of the remaining seventeen food crops which I discussed, five probably composed the major part of the remaining plant diet. Ají, camote, pepino, maní, and pacae probably served as secondary cultigens during the Chimu period, while cotton probably constituted the most extensively cultivated of the industrial plants.

The following table presents a brief summary of the evidence supporting the inclusion of the twenty-seven plants discussed above as Chimu cultigens.

Table 11. Cultigens and the evidence supporting their use during the Chimu Period on the north coast of Peru.

CULTIGENS	ETHNOHISTORIC EVIDENCE[1]	ICONOGRAPHIC EVIDENCE[2]	ARCHAEOLOGICAL EVIDENCE[3]
GRAIN *Zea mays* (maize,corn)	(Pizarro 1533; Jerez 1534; Estete 1535; Cieza 1535; Betanzos 1551; Acuna 1586; Garcilaso 1609-17; Contrera 1650; Cobo 1653)	(Donnan and Mackey 1978; 308-9,MC7:1, 320-25,MC11:1,MC12:1, 330-32,MC14:2; Yacovleff and Herrera 1934-35:259, figs.5c-d)	Chan Chan SIAR[4] Chan Chan Rivero Caracoles Co. La Virgen Choroval
LEGUMES *Arachis hypogea* (mani,peanut)	(Oviedo and Valdez 1535; Garcilaso 1609-17)	(Disselhoff 1967:49-mochica; Tello 1938: 187-mochica)	Chan Chan SIAR Chan Chan Rivero Caracoles Choroval
Inga feullei (pacae,guava)	(Estete 1535; Oviedo and Valdez 1535; Diego Palomino 1549; Acosta 1590; Garcilaso 1609-17)	(Towle 1961:Pl.IX,b; Yacovleff and Herrera 1934-35:251,fig.1b)	Chan Chan SIAR Chan Chan Rivero Caracoles Co. La Virgen Choroval
Phaseolus lunatus (pallar,lima bean	(Oviedo and Valdez 1535; Cieza 1535; Valverde 1539; Perez 1545; Betanzos 1551; Acosta 1590; Morua 1590; Garcilaso 1609-17; Cobo 1653)	(Tello 1938:116,117-mochica)	Caracoles Co. La Virgen Choroval
Phaseolus vulgarus (frijol,common bean)			Chan Chan SIAR Chan Chan Rivero Caracoles Co. La Virgen Choroval

Table 11. (Continued)

CULTIGENS	ETHNOGHISTORIC EVIDENCE[1]	ICONOGRAPHIC EVIDENCE[2]	ARCHAEOLOGICAL EVIDENCE[3]
Prosopis chilensis (algarroba)	(Oviedo and Valdez 1535; De las Casas 1550; Cobo 1653	(Larco Hoyle 1938-39: 80, fig. 41-mochica; Yacovleff and Herrera 1934-35:292, fig. 20-mochica)	Chan Chan SIAR Chan Chan Rivero Caracoles Co. La Virgen Choroval
FRUITS Annona chirimolia (chirimoya)	(Cobo 1653)	(Tello 1938:106,107, top?)	
Annona muricata (guanabana, soursop)	(Oviedo and Valdez 1535; Cobo 1653)	(Yacovleff and Herrera 1934-35:253, fig. 1f; Tello 1938:107, bottom ?)	Chan Chan SIAR Chan Chan Rivero Caracoles Co. La Virgen Choroval
Bunchosia armeniaca (cansaboca, ciruela)	(Oviedo and Valdez 1535; Garcilaso 1609-17; Cobo 1653)	(Towle 1961:Pl.XII; Tello 1938:108, left cyphomandra?; Yacovleff and Herrera 1934-35:264, fig. 8d)	Chan Chan SIAR Chan Chan Rivero Caracoles Co. La Virgen
Cucurbita sp. maxima (zapallo, squash) moschata (calabaza)	(Oviedo and Valdez 1535; Acosta 1590; Garcilaso 1609-17; Cobo 1653)	(Donnan and Mackey 1978:341,Pl.17,LC1 2:1,344-347,LC1,2:1; Yacovleff and Herrera 1934-35:302;fig.26c; Larco Hoyle 1938-39: 24,fig.32)	Chan Chan SIAR Chan Chan Rivero Caracoles Co. La Virgen Choroval

Table 11. (Continued)

CULTIGENS	ETHNOHISTORIC EVIDENCE[1]	ICONOGRAPHIC EVIDENCE[2]	ARCHAEOLOGICAL EVIDENCE[3]
Cyclanthera pedata (caigua)	(Varios 1582; Cobo 1653)		Carocoles Co. La Virgen Choroval
Cyphomandra sp. (pepino,tree tomato)		(Safford 1917:21,fig. 5; Tello 1938:112?, 108, left?)	
Lucuma bifera (lucuma)	(Estete 1535; Oviedo and Valdez 1535; Cieza 1535; Valverde 1539; Diego Palomino 1549; Velasco 1574; Fornee 1586; Garcilaso 1609-17)	(Infantes 1962:165, fig. 12b; Tello 1938:111-mochica)	Chan Chan SIAR Chan Chan Rivero Caracoles Co. La Virgen Choroval
Persea americana (palta, avocado)	(Oviedo and Valdez 1535; Cieza 1535; Valverde 1539; Garcilaso 1609-17)		Chan Chan SIAR Chan Chan Rivero Caracoles Co. La Virgen Choroval
Psidium guajava (guayaba,guava)	(Oviedo and Valdez 1535; Cieza 1535; Valverde 1539; Monardes 1580; Morua 1590; Garcilaso 1609-17)		Caracoles
Solanum muricatum	(Oviedo and Valdez 1535; Cieza 1535; Cobo 1653)	(Towle 1961:Pl. XIIIA-mochica; Tello 1938:113,114-mochica)	

Table 11. (Continued)

CULTIGENS	ETHNOHISTORIC EVIDENCE[1]	ICONOGRAPHIC EVIDENCE[2]	ARCHAEOLOGICAL EVIDENCE[3]
Solanum peruvianum (tomatillo)	(Cobo 1653; Acosta 1590)		Caracoles Choroval
ROOTS AND TUBERS Canna edulis (achira)	(Diego Palomino 1549; Cobo 1653)	(Yacovleff and Herrera 1934-35:311, fig. 30b)	
Ipomoea batatas (camote, sweet potato)	(Oviedo and Valdez 1535; Valverde 1539; Diego Palomino 1549; Garcilaso 1609-17; Cobo 1653)	(Herrera 1942:189, figs. 2,4-mochica; Tello 1938:90-mochica,91-Chimu-Inca?)	Co. La Virgen
Manihot esculenta	(Oviedo and Valdez 1535; Cieza 1535; Cobo 1653)	(Disselhoff 1967:49 bottom left-mochica; Larco Hoyle 1966:95, fig. 56-mochica; Tello 1938:89-mochica; Yacovleff and Herrera 1934-35:253, fig. 1a-mochica, fig. 1d-Inca	
Solanum tuberosum (papa, potato)	(Oviedo and Valdez 1535; Cieza 1535; Valverde 1539; Garcilaso 1609-17; Cobo 1653)	(Larco Hoyle 1966:98, 99, fig. 62,63-mochica; Salaman 1949; Pl. 4,5, figs. 8-12-Chimu Inca? Tello 1938:92-Chimu?, 93-Mochica,94-Chimu-Inca?)	

Table 11. (Continued)

CULTIGENS	ETHNOHISTORIC EVIDENCE[1]	ICONOGRAPHIC EVIDENCE[2]	ARCHAEOLOGICAL EVIDENCE[3]
CONDIMENTS *Capsicum sp.* *annuum* (aji) *frutescens*	(Oviedo and Valdez 1535; Valverde 1539; Betanzos 1551; Morua 1590; Garcilaso 1609-17; Cobo 1653)	(Yacovleff and Herrera 1934-35; 277, fig.12e)	Chan Chan SIAR Chan Chan Rivero Caracoles Co. La Virgen Choroval
NUTS *Juglans neotropica* (nogal,walnut)	(Varios 1582; Acosta 1590; Cobo 1653)		Co. La Virgen
CONTAINERS *Lagenaria siceria* (calabazo,gourd)	(Cieza 1535; Diego Palomino 1549; Lizarraga 1555-1609; Cobo 1653)	(Yacovleff and Herrera 1934-35:314, fig. 31a-b)	Chan Chan SIAR Chan Chan Rivero Caracoles Co. La Virgen Choroval
FIBER PLANTS *Gossypium* *barbadense* (algodon, cotton)	(Jerez 1534; Oviedo and Valdez 1535; Cieza 1535; Betanzos 1551; Lizarrage 1555-1609; Cobo 1653)		Chan Chan SIAR Chan Chan Rivero Caracoles Co. La Virgen Choroval
Scripus tatora (totora reed)	(Estete 1535; Oviedo and Valdez 1535; Cieza 1535; Betanzos 1551; Lizarrage 1555-1609; Cobo 1653)	(Larco Hoyle 1938-39: 129, fig. 111, 137, fig. 127-mochica; Vargas 1962:115, fig. 26-mochica)	Caracoles Co. La Virgen Choroval

1. Chroniclers and dates identified by Yacovleff and Herrera (1934-35)
2. References containing illustrations of iconographic representations. Unless otherwise noted, representations are found on Chimu vessels.
3. Chimu Period sites excavated by Pozorski (1976).
4. Small Irregular Agglutinated Rooms

PREHISTORIC AGRICULTURAL TECHNOLOGY AND WATER CONTROL

Agriculture as an adaptive mechanism functions to produce artificial ecosystems from which human groups can extract biological products for the sustenance and maintenance of the group. The production and the nature of these specialized systems is the direct result of the interaction of agricultural technology and natural environment. Agricultural technology as it is used in this sense refers to a very broad range of activities and specialized knowledge which is applied to produce, maintain, and harvest these specialized ecosystems.

The entire range of agricultural techniques and activities is not preserved in the archaeological record or documented in the ethnohistoric sources. It is only possible, therefore, to reconstruct certain aspects of prehistoric North Coast agricultural technology. Fortunately, the desert environment and changes in land use patterns have preserved large canal systems and extensive areas of prehistoric fields. The intensive study of these systems in conjunction with iconographic and ethnohistoric evidence and by analogy with modern traditional farming can shed considerable light on Chimu agricultural technology. In addition, modern techniques for the evaluation of irrigation systems can be fruitfully applied to prehistoric systems. These techniques can further our understanding of the efficiency and level of technological expertise attained by the late prehistoric populations of the North Coast.

As I discussed in the chapter on prehistoric cultigens, it

is of the utmost importance that the limitations of the evidence be well understood. In this case, the limitations of the archaeological, iconographic, and ethnohistoric evidence are very much the same as discussed earlier. In the case of analogy with modern traditional farming, the limitations given for ethnohistoric data generally hold true, with several additional limitations as well. All analogies must be undertaken with a great deal of care. The social and political changes which have taken place on the North Coast in the past four hundred to five hundred years have drastically altered the patterns of agricultural production. However, remnants of the prehistoric patterns can provide valuable insight into the nature and functioning of the prehistoric systems (Gillin 1947; Sabogal 1976). Analogies are best used to formulate hypotheses which can be tested through the use of additional independent data.

The most elaborated aspect of prehistoric agricultural technology on the North Coast was, without a doubt, irrigation. The control and distribution of water is essential to the exploitation of the coastal regions. Unfortunately, irrigation remains are inadequately studied, and their distribution within even a single valley on the North Coast is poorly known. Work conducted by the late Paul Kosok (1960; 1965) focuses on the distribution and extent of the large trunk canals (acequia madre) found in several North Coast valleys. He did not, however, discuss the distribution or nature of the smaller features or the more technical aspects of prehistoric irrigation. However, access to Kosok's unpublished notes and maps, unpublished

theses and dissertations (Kus 1967, 1972; Netherly 1977), manuscripts (Kosok n.d.; Rodriguez Suy Suy 1971), personal field notes, and the published materials should prove adequate to allow a reasonable reconstruction of Chimu irrigation technology.

Canal Irrigation

Reliance on the highly variable discharges of the coastal rivers for irrigation poses a major problem in regard to increasing agricultural production. Using only the available river water for irrigation, the maximum extent of cultivation is determined by the minimum discharge available during the growing season. If, for example, crops are planted immediately following the spring floods in order to take maximum advantage of available soil moisture, sufficient irrigation water for efficient flower and fruit production may not be available for certain crops due to decreased river discharge.

In order to maintain a high level of production under these conditions, it is necessary to either increase the amount of land under cultivation or to supply additional irrigation water from another source. By placing more land under cultivation and relying primarily on the available soil moisture, crop yields per hectare are low, but due to the large area of cultivation, total production remains high. An alternative approach is to cultivate less area, but to increase production by the application of additional water during the critical periods of flowering and fruit production. This may be accomplished by removing water from aquifers or by storing excess water in impoundment reservoirs during periods of high river

discharge for release during periods of low river discharge.

During the prehistoric period, the exploitation of subsurface water seems to have been restricted to those areas where aquifers outcropped as flowing springs which could be diverted into canals. At present, there is no evidence that water was removed from wells for the purposes of irrigation. This may, however, be the result of limited investigations rather than prehistoric practices.

Both extensive cultivation of large areas using only the available river water and intensive cultivation using stored water have been postulated for the prehistoric North Coast. It has generally been assumed that prehistoric cultivation in the lower coastal valleys was entirely dependent on the available river water for irrigation. Recently, however, there has been increasing interest in the possibility that artificial impoundment reservoirs, or embolsamientos, were used during the prehistoric period (Eling 1978; Rodriguez Suy Suy 1971). Before discussing this possibility in detail, however, it is necessary to understand the nature of the larger irrigation system with which they would articulate.

On one level it is important to view canal irrigation as a dynamic physical system governed by physical laws. As a dynamic system, an irrigation system is constantly adjusting its parameters in response to changes in the amount and distribution of energy within the system. The goal of the irrigation engineer, then, is to design and construct a system which, upon reaching a dynamic equilibruim, will deliver a given quantity of water from point A (the Chicama

River, in this case) to point B (the root zone of the cultivated plants). The engineer must therefore design and construct a system which will function under a variety of energy regimes with a minimum of maintenance.

Irrigation systems based on the diversion of water from a large permanent river can be broken down into several component parts: intake or bocatoma, channel or acequia, aqueduct or aqueducto, drop structures, turnouts, and field systems and subsystems. Each of these components can, within limits, adjust its parameters to account for variations in the amount of energy entering and flowing through the system. In this case, the energy is in the form of flowing water.

The amount of water available for irrigation and, ultimately, the amount of land which may be cultivated from a single canal system is primarily dependent upon the nature and location of the bocatoma. The location of the intake, in conjunction with the slope of the canal channel, determines what land may be cultivated. Only that land lying below the elevation of the canal can be irrigated without the use of water lifting technology. Such technology has not been documented for Pre-Columbian Peru. The size and location of the bocatoma, relative to those of other canals, determine the amount of water which could be diverted from the river. During periods of decreased river discharge, intakes located farther downstream may have had access to a smaller percentage of the river discharge as a function of the amount of water diverted by higher bocatomas. Kus (1972:123) has suggested that those canals having their intakes below that of the

Chicama-Moche Canal were probably in this situation. The centralized control of bocatomas, as might be expected in the case of the Chicama Valley during the Chimu Empire, could have easily moderated these effects, however.

The amount of water available to bocatomas is also a function of their location relative to the river channel. More water is readily available to intakes located on the outside of river bends than on the inside. The location of the deepest part of the channel, along the outside of a bend, means that a shorter wing dam can be used to divert the desired amount of water than if it were located on the inside of the bend. In addition, bocatomas located on the inside of a bend will require more maintenance to keep the intake free of sediment deposited by the lower velocities in that part of the river channel (see Figs. 4 and 5D).

There is no archaeological evidence upon which to base a reconstruction of the form of prehistoric bocatomas. It is assumed that they closely approximated the modern bocatomas referred to as rústicas (Eling 1978:403; Kus, et al., 1977).

These more traditional forms of bocatomas consist primarily of a wing dam to divert water into the canal and generally lack headgates and debris grates. The wing dams of these modern canals are constructed of wood, stone, and brush which is supported by large wood or steel tripods anchored in the river bed. With the usual exception of the tripod supports, the wing dams are unlikely to survive the annual spring floods. They do not, however, represent tremendous

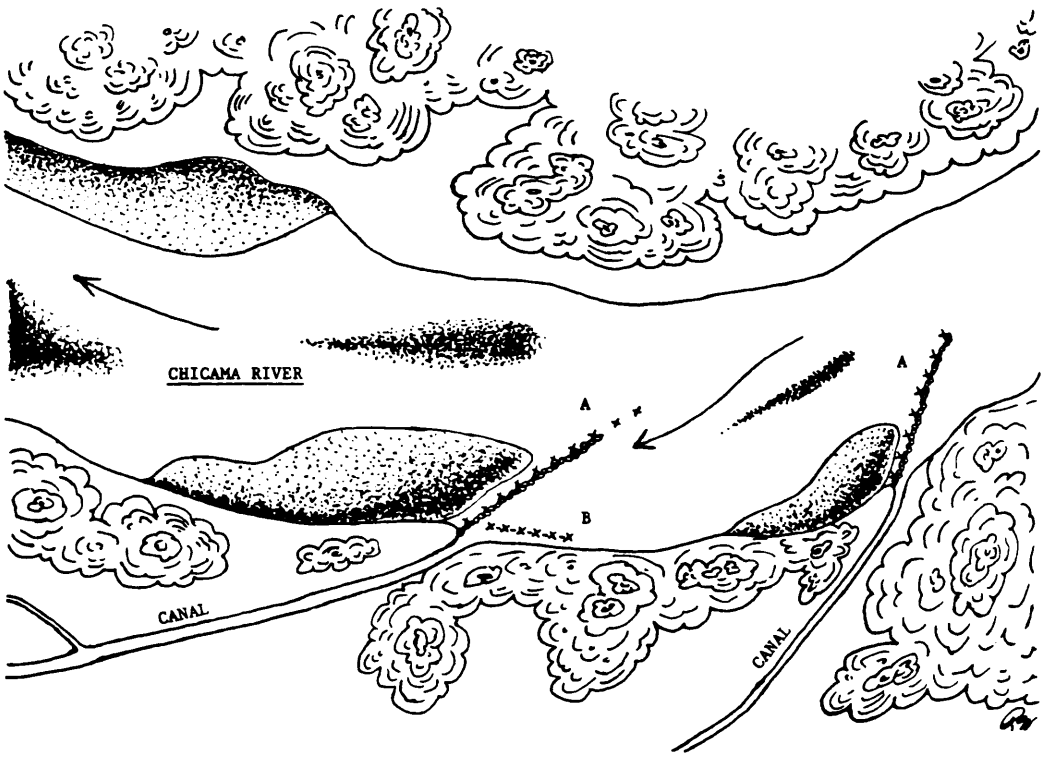


Figure 4. Bocatomas rusticas. A.- wing dams. B.- protective bank structures.

expenditures of energy and can easily be replaced.

The fact that these structures are not permanent may serve to protect the canal system in the absence of a headgate. During periods of high river discharge, these temporary structures would be washed out and would no longer function to divert water into the canal. A more permanent structure would continue to direct an increased flow of water into the mouth of the canal which, without headgates to hold it back, would enter the canal and severely erode the channel. If the flow was of sufficient volume and velocity, it could conceivably wash out sections of the channel, thereby destroying not only the canal,

but also the field systems and potentially houses and other buildings as well.

Evidence indicates that just such an event occurred during the recent historic period, probably during the 1925 El Niño. A large section of the old Ascope canal, a rehabilitated prehistoric canal which crossed the famous Ascope Aqueduct, is washed out approximately one kilometer northeast of the former hacienda Facala. Concrete repairs to the canal channel indicate that it was used during the recent past. In addition, the form and location of the breach indicate that it was water flowing through the channel which caused the canal to fail. This section of the canal was subsequently abandoned. It is likely that similar canal failures occurred during the prehistoric period, in spite of the impermanent diversion structures. A careful study of some of the extant remains would probably reveal periods of rebuilding of specific sections due to this type of failure.

The absence of headgates means that the precise control of the amount of water entering the canal system is considerably more difficult. It can be accomplished to a limited extent by changes in the position and length of the wing dam. To shut off or highly restrict the flow of water entering the canal, a small wood and earth dam is placed across the channel a short distance from the mouth of the canal (see ONERN 1973 1:Foto No. 22).

Debris grates on modern concrete bocatomas serve to prevent large water-borne debris such as logs and boulders which might damage or clog the channel from entering the canal (see ONERN 1973 1: Fotos

Nos. 24, 26-27). This function is served by structures very similar to wing dams. Large tripods or quadrupods of wood or steel are anchored in the river bed near and parallel to the river bank. Wood or metal poles connecting these structures catch or divert any debris which might damage the canal. These structures not only serve to protect the irrigation canals, but also those fields which border directly on the river (see ONERN 1973 1:Foto Nos. 22, 29).

As I noted above, there is no archaeological evidence to indicate the form of prehistoric bocatomas. It is unlikely that any have survived the numerous annual floods and catastrophic El Niños which have occurred since their abandonment. However, studies of the numerous bocatomas rústicas found on the North Coast could lead us to a better understanding of the technology of water control for the prehistoric period.

As a dynamic component of an irrigation system, the canal channel is probably the best understood. The channel of an irrigation system serves to direct the flow of water diverted from the river to the field systems.

There are two primary characteristics of water flow in open channels which are of major concern to the irrigation engineer: velocity and discharge. Velocity (V) is defined in terms of the distance the water moves in a specified unit of time and is measured in meters per second, feet per second, etc. Discharge (Q) is defined as the volume of water which passes a given point in a specified unit of time. It is expressed as the product of the cross-sectional area

of the flow (A) and the Velocity (V) -- Q = AV. Discharge is measured in cubic meters per second, cubic feet per second, etc.

The velocity of the flow in an open channel is a direct function of three primary variables: slope (S), hydraulic radius (R), and the relative roughness of the channel sides and bottom (n). Slope refers to the slope of the water surface, expressed as m/m, ft/ft, etc., which in a channel of uniform flow is equal to the slope of the bed. The hydraulic radius is equal to the quotient of the cross-sectional area of the flow (A) divided by the wetted perimeter of the flow in contact with the channel (P) -- R = A/P. The relative roughness of the channel can be expressed as a coefficient of roughness called Manning's "n" which varies with the surface of the channel. Using these variables, velocity can be defined as:

$$V = \frac{1.00}{n} R^{2/3} S^{1/2}$$

in metric units.

Not only is velocity important for its relationship to discharge, but also for its effect on the relative degree of deposition and erosion which occur within the channel. Numerous attempts have been made to define limits within which canals constructed in erodible material will be stable (Lane 1953; Simons and Albertson 1963). The results of these studies, however, are not totally acceptable. It has proven impossible up to this point to derive an empirical relationship which, when applied to all cases, will define the limits within which a canal will be stable. Terrell and Borland, in reference to this

fact, have described the state of the art:

> The problem of stable channels is complex. The type of engineering concerned with this problem does not lend itself to precise design and depends on the judgement, experience, and skill of the engineer (1958:115).

In spite of the empirical relationships such as those in the references listed above, the design of irrigation systems is still inferential. The advances found in modern systems are more the result of technical advances in construction than the integration of a precise knowledge of open channel flow and engineering expertise. The modern irrigation engineer then, has considerably more information available, but does not always understand the relationships which are significant to the design of stable channels. None the less, by evaluating prehistoric canals in terms of models such as the tractive force model, we can better understand the level of sophistication attained by the prehistoric irrigation engineers. Unfortunately, the data necessary for this evaluation is not available and must await further research.

Of the three variables affecting velocity, two are most commonly used by irrigation engineers to control the velocity of the flow: hydraulic radius and slope. The third variable, roughness of the channel bed, is difficult to control, and efforts are generally made to maintain the smoothest possible channel. The hydraulic radius, as I mentioned above, is a combination of the cross-sectional area and the wetted perimeter of the flow. These two variables can be more readily controlled than can the channel roughness by simply changing

the form of the channel cross-section and regulating the amount of water entering the system.

Velocity within an open channel is not uniform throughout the cross-section of the flow (see Fig. 5). The highest velocity occurs near the center of the channel where the least resistance to flow is encountered. Nearer the sides and bottom of the channel, velocity is reduced by increased turbulence due to friction at the interface between the channel surface and the water. By understanding these principles, the irrigation engineer can change the velocity of flow by simply changing the cross-section of the channel. A broad shallow channel, for example, will have a slower velocity than will a channel which is approximately as deep as it is wide if both have the same cross-sectional area, roughness, and slope. This can be accounted for by the fact that the shallower canal will have a much larger percent of its volume in contact with the channel, i.e., a larger wetter perimeter, which will serve to retard the flow.

Changes in direction also affect the distribution of velocities within the channel (see Fig. 5). Due to inertia, the area of maximum velocity is displaced from the center of the channel toward the outside of the bend. This increased velocity nearer to the side of the channel may cause increased erosion of the outer edge of the channel (in some materials) with increased deposition occurring on the inside edge. By changing the cross-section of the channel to reduce the velocity, damage to the canal can be minimized or eliminated under normal flow conditions. Lining of the channel bends with a material

more resistant to erosion can also alleviate this problem.

Velocity can also be controlled by changes in the slope of the bed. The steeper the channel bed, the higher the velocity. Changes in the slope of different sections of an irrigation channel can also be used to increase or decrease the velocity of flow in order to prevent sedimentation and/or erosion.

It is sometimes necessary to convey water down steeper slopes than are stable with the resulting increased velocity. In these cases, the channel can be lined with a material resistant to erosion or it can be built in sections divided by drop structures. Drop structures are grade control structures used to reduce erosive flow velocities in unlined channels. Constructed of wood, concrete, masonry, or other non-erodible material, drop structures lower the water over a short horizontal distance and dissipate the energy of the flowing water to reduce the potential for erosion. Several drop structures serving as overflows have recently been described for the Intervalley Canal and the Pampa Huanchaco canals investigated by the Programa Riego Antiguo (Ortloff n.d.; Ortloff, et al. n.d.).

In order to attain the desired velocity, the canal must be constructed with an appropriate slope. This slope must be maintained throughout virtually the entire length of the channel. The nature of the terrain to be crossed by the canal between the toma and the fields to a large extent determines the form which the canal will take. If the area is relatively flat or only gently sloping, the channel can be excavated with relatively little difficulty beyond maintaining the

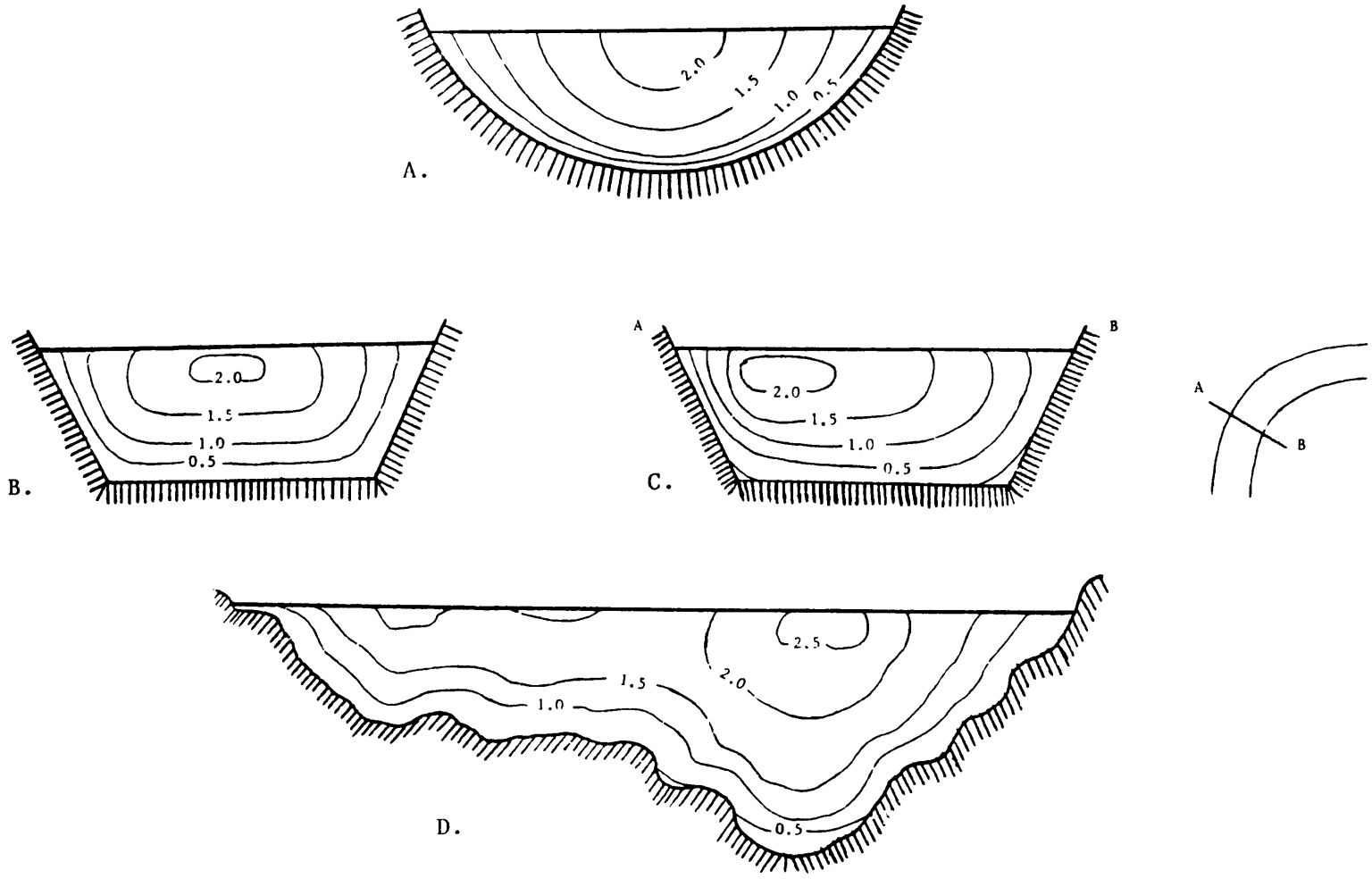


Figure 5. Typical curves of equal velocity in various channel-sections. Redrawn and adapted from (Chow 1959:25).

desired slope. However, if the area is very rough, the channel must be constructed to roughly follow a contour around the edges of the hills and gullies. The latter is the case of the large prehistoric trunk canals which carried water to the far north and south banks of the Chicama Valley. In this case, the channel may be either excavated into the sides of the hills and across the upper ends of the gullies, constructed on top of an artificial embankment built to follow the desired contour, or some combination of the two.

There are three alternative means by which a canal can be conveyed from one side of a gully or quebrada to the other. The first is simply to follow the contour of the canal along the side of the quebrada until it intersects the floor and can be carried across to the other side. This method involves the construction of a considerably longer length of canal than either of the other two alternatives. The second method is to construct an aqueduct across the quebrada on which the canal can be carried at the appropriate slope. The use of aqueducts on the prehistoric North Coast was restricted to the construction of earth embankments extending across dry quebradas. A major difficulty encountered with both of these methods is their susceptibility to destruction by flash flooding. Flooding of the numerous quebradas is an unusual occurrence. However, when it occurs as the result of an El Niño or huaico, it is catastrophic. The third method consists of a pipe, called an inverted siphon, which conveys water across deep depressions or canyons under pressure. Water enters the pipe which slopes down the side of the depression creating

sufficient head to lift the water up the far side of the depression. The major advantage to the inverted siphon is that, lying at or near the bottom of a gully, it forms less of an obstruction to natural runoff and is not as subject to damage as the embankment aqueducts or open channels. No evidence for the use of this technique has been found on the North Coast for the prehistoric period. Our present knowledge of the technological capabilities of the prehistoric Peruvian populations indicates that they probably did not have the technological expertise to construct an inverted siphon. Again, however, further investigations must be made before the possibility is entirely dismissed.

Not all of the water which enters the mouth of the canal is available to the fields. Considerable quantities of water can be lost between the bocatoma and the field systems. Evaporation from the surface of the channel, evapotranspiration from phreatophytes, and seepage through the channel sides and bed account for the greatest percentage of water lost from the channel.

Evaporation directly from the surface of the channel probably accounts for only 1.0 percent to 1.5 percent of the diverted water (Lauritzen and Terrell 1967:1105). This amount can, however, be significant in large systems operating with a limited water supply, such as the late prehistoric systems on the North Coast.

Phreatophytes are any plants growing where their roots are in free water, and which are extracting water directly (Burgy, Fletcher and Sharp 1967:1096). These plants grow in and along irrigation canals

and have very high rates of evapotranspiration. Not only is a tremendous amount of water lost directly to these plants, but their growth in the channel can significantly reduce the velocity of flow and, hence, the discharge. In some cases, they may also induce sedimentation and filling of the channel. As an indication of the potential severity of water lost to evapotranspiration from phreatophytes, the Salt Cedar, Tamarix gallica, has been estimated to consume from 15,000 to 27,000 cubic meters of water per hectare annually in the American Southwest (Jensen, Swarner and Phelan 1967: 1131). Similar plants most assuredly occur on the North Coast.

Seepage of water through the sides and bed of the channel not only results in the loss of irrigation water, but may also result in problems of waterlogging and sodium or salt accumulation in adjacent soils. Since water losses by seepage are primarily governed by permeability, they can be significantly reduced by the presence of a natural or artificial lining of the channel bed and sides, both of which are found in prehistoric North Coast canals.

Water is delivered to the field systems through secondary canals called laterals. Laterals vary considerably in size and length and may serve field systems of from less than one hectare in area to those covering hundreds of hectares.

In order to divert water from the main canal into the laterals, a structure called a turnout is used. Turnouts can be either open channels which direct water through a cut in the bank of the canal or conduits extending through it. The use of conduits

has not been demonstrated for the prehistoric North Coast. Open channels were used, however, and will be described in more detail later.

To use a turnout, a temporary dam or check is placed a short distance downstream causing the water to pool, providing a constant head for conduit turnouts or a higher water level for open channel turnouts. Canvas, plastic, or rubber sheets are generally used to construct these temporary structures in modern irrigation systems. However, dams of cane or brush and earth are not uncommon even today on the North Coast. Presumably, similar structures were used by the prehistoric inhabitants, but insufficient archaeological work has been carried out to determine the exact form which was used.

Field systems from an irrigation perspective consist of the actual agricultural fields and the canals which border and provide water directly to the fields. Field systems are characterized by the manner in which irrigation water is applied. Four types of surface irrigation have been defined on this basis: uncontrolled flooding from field ditches, border strip flooding, check flooding, and furrow irrigation. The last three of these types are known from the North Coast, and it is not unlikely that the first will be found as research continues.

Uncontrolled flooding from field ditches consists of applying water directly from ditches without any dikes or levees to control flow across the field (see Fig. 6). The topography of the field to a large extent controls the flow of water across its surface. Uneven

water distirbution and low application efficiencies are common with this system of irrigation.

Border strip flooding involves the controlled inundation of essentially very broad shallow channels. Fields are divided by borders of levees into long narrow strips which run parallel to the slope. These strips are irrigated by introducing water from a field ditch running across the slope at the top of the strip (see Fig.). This type of irrigation is commonly used on fields with slopes ranging from 0.1 percent to 1.0 percent for most crops. It may, however, be used on slopes up to 6.0 percent for crops with a high density and good ground cover such as in pastures. The water should flow evenly across the entire width of the strip which is usually from 9.0 to 18.0 meters wide for modern fields. The length and width of border strips varies with the topography and soils of the fields. Kus (1972:168-170) has described border strip fields at the Quebrada de Oso site, a late prehistoric site located in the Chicama Valley.

Check flooding consists of inundating relatively level plots surrounded by borders (see Fig. 6). It is well suited to highly permeable soils where it is necessary to rapidly supply water to plots to avoid excessive losses to deep percolation, and to slowly permeable soils requiring considerable periods of time to absorb sufficient water. The size of the checks or basins, like border strips, is related to the soils and topography of the fields. This type of irrigation is best adapted to relatively flat level land which minimizes the requirements for grading and leveling of the fields.

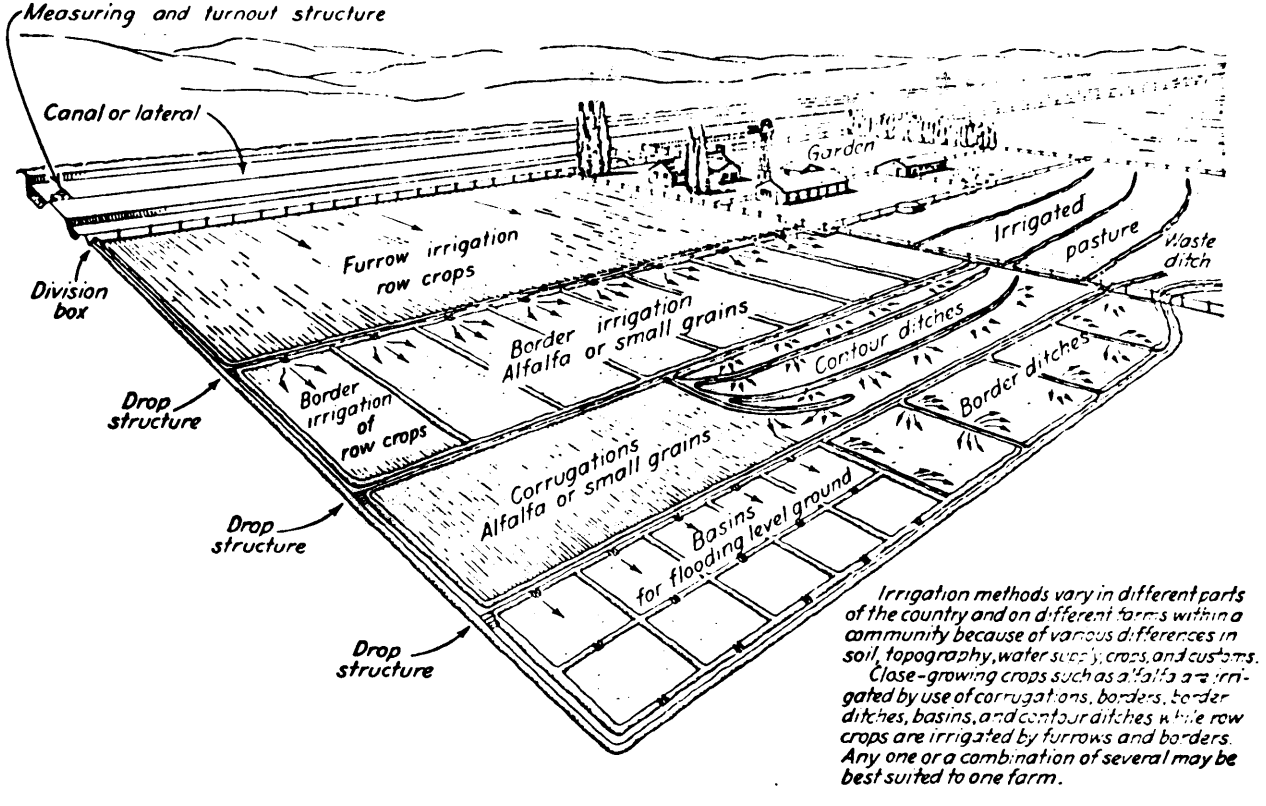


Figure 6. Methods of surface irrigation, reproduced from Israelsen and Hansen (1962:289).

Check flooding has been reported for the North Coast by several investigators (Johnson and Platt 1930; Larco Hoyle 1946; Willey 1953). Willey (1953:366-367, fig. 22, pl. 54) presents the most complete description of check fields available. In addition, he provides a map and photograph illustrating a field system.

> Near the south side of the mouth of the quebrada there is an area 350 by 150 meters which consists, solidly, of small rectangular cultivation plots (see fig. 22) (pl. 54, top). A distributary canal follows along at the top and at the bottom of these plots. The plots vary somewhat in size, but 2.5 by 3.5 meters would be an average. The partitions of these little rectangles, which have the appearance of screen-wire mesh in the air photographs, are lines of rock 50 to 30 cm. wide and of about the same height. There is no masonry; the rock (of small size) has simply been piled in rows. The floors of the rectangles are fairly free from rock and are filled with silt. Each rectangle is a completely closed pen in that there are no openings through the ridges from one pen to another. The whole would have been irrigated by turning water in from the top and letting it gradually fill the numerous rectangles, beginning with those on a higher elevation and slowly overflowing down slope. Overflow water would have been caught in the canal passing below the plots and carried off (Willey 1953:366).

This field system most likely dates to the Tomoval (Middle Horizon) and/or La Plata (Late Intermediate) Periods (Willey 1953:367).

Furrow irrigation is the application of water to agricultural fields by confining it to small shallow channels or furrows (see Fig. 6). Infiltration occurs through the sides and bottom of the furrows. The use of furrow irrigation limits water loss from evaporation by greatly restricting the exposed surface area of the irrigation water

over that of the other techniques discussed. Furrows can take a variety of forms in order to achieve special results. Contour furrows running across the slope serve to help control erosion, for example, and small parallel furrows, called corrugations, can be used to increase the efficiency of border flooding. The use of furrow irrigation is perfectly adopted to the irrigation of row crops since the furrows are constructed as part of the cultivation process. Table 12 presents a summary of the adaptations, limitations, and advantages of these various methods of irrigation.

The importance of soil characteristics in designing and constructing field systems cannot be overlooked. Such variables as texture, permeability, erodibility, salt content, and internal drainage capacity, as well as several others must be included if the system is to function efficiently and to its maximum capabilities. As I noted in the chapter on soils, these variables have been incorporated into a system of land classification for irrigation agriculture which has been applied to the Chicama Valley. In a later chapter, I will discuss the implications of this classification for reconstructing prehistoric agricultural technology.

The hydraulics of surface irrigation are very complex, and it is only recently that models have been developed to account for and predict those parameters most essential to efficient irrigation (Bishop, Jensen, and Hall 1967).

Unfortunately, no prehistoric irrigation systems have been studied in sufficient detail to evaluate them from all of these

Method	Adaptation	Limitations	Advantages
		Flooding	
From field ditches	1) All irrigable soils 2) Close growing crops 3) Slopes up to 10% 4) Rolling lands and shallow soils where land grading is not feasible	1) Subdivides fields 2) High irrigation labor requirements 3) Low water application efficiency 4) Uneven water distribution 5) Possible erosion hazard	1) Low initial cost 2) Adaptable to a wide range of irrigation flows 3) Few permanent structures 4) Runoff from upper areas can be collected and reused
Border strip	1) All irrigable soils 2) Close growing crops 3) Slopes up to 3% for grains and forage crops 4) Slopes up to 7% for pastures	1) Extensive land grading required 2) Engineering designs necessary for high efficiencies 3) Relatively large flows required 4) Shallow soils cannot be economically graded * 5) Dikes hinder cultivation and harvesting	1) High water application efficiency possible with good design and operation, regardless of soil type 2) Efficient in use of irrigation labor 3) Applicable on all soil types 4) Low maintenance costs 5) Positive control over irrigation water
Checks or level basins	1) All irrigable soils 2) Orchards and close growing crops 3) Slopes up to 2½% or more when benched or terraced	1) Extensive land grading often required 2) Large flows required 3) Initial cost relatively high * 4) Dikes hinder equipment operations 5) Maintenance problems on escarpments on steep slopes 6) May effect crop yields on crops sensitive to inundation	1) Good control of irrigation water 2) High water application efficiency 3) Uniform water applications and leaching 4) Low maintenance costs 5) Erosion control from irrigation and rainfall 6) Large streams can be utilized
		Furrow irrigation	
Corrugations	1) All irrigable soils 2) Slopes up to 10% 3) Close growing crops	1) Moderately high irrigation labor requirements 2) Short runs required on high intake soils * 3) Rough on cultivation and harvesting equipment	1) Increase efficiency and uniformity over flooding from field ditches on rolling lands 2) Improves border flooding on new lands
Furrow	1) All row crops 2) All irrigable soils 3) Slopes up to 5% with rowcrops and up to 15% for contour furrows in orchards	1) Moderate irrigation labor requirements 2) Engineering design essential for high efficiencies 3) Some runoff usually necessary for uniform water application 4) Erosion hazard on steep slopes from rainfall	1) Uniform water applications 2) High water application efficiency 3) Good control of irrigation water * 4) Control equipment available at low cost such as spiles, siphon tubes and gates

Table 12. Adaptations, Limitations, and Advantages, of Surface Irrigation. Reproduced from Bishop, Jensen, and Hall (1967:870).

* Applicable only to plow and mechanized agriculture - not relevant to prehistoric agriculture in Peru.

perspectives (see Fig. 7).

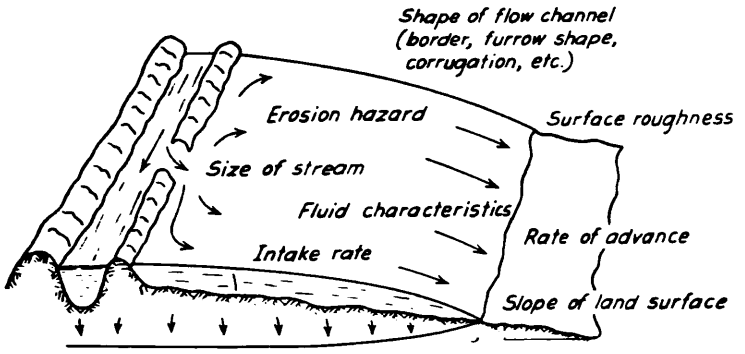


Figure 7. Schematic view of border irrigation illustrating the basic variables involved in the hydraulics of surface irrigation, from Israelsen and Hansen (1962:309).

As I mentioned earlier, it has been suggested that artificial impoundment reservoirs were constructed by the prehistoric coastal inhabitants to augment available irrigation water during periods of low river discharge. Unfortunately, no detailed studies have been carried out on any of these structures.

There are references to at least nine structures which have been described as reservoirs on the North Coast. The earliest reference to impoundment reservoirs is found in Squier (1877), in which he discusses a reservoir which he located in the Nepeña Valley:

> It is on the desert Pacific coast of Peru, however, where no vegetation could otherwise exist, except on the immediate banks of the streams descending from the Cordillera, that we find the most extensive irrigating works of the ancient inhabitants. They not only constructed dams at different elevations in the stream, with side weirs to deflect the

> water over the higher slopes of the valleys, but built enormous reservoirs high up among the mountains, as well as down nearer the sea, to retain the surplus water of the season when the snows melted, and the rains fell in the interior. One of these reservoirs in the valley of the Nepeña is three-fourths of a mile long by more than a half a mile broad, and consists of a massive dam of stone eight feet thick at the base, carried across a gorge between two lofty, rocky hills, It was supplied by two canals at different elevations; one starting fourteen miles up the valley of the Nepeña, and the other from living springs five miles distant (Squier 1877:219).

Wiener (1880:542-543) and Mozans (1911:289-290) both describe a reservoir called "Màmposteria" in the Moche Valley. In an earlier reference, Squier describes a large aqueduct constructed of stone and adobe which is probably the same structure. In 1971, Rodriguez Suy Suy again referred to this structure, this time as "Mampuesto." Farrington (1974:91) makes passing reference to another reservoir in the Moche Valley, located at the junction of the La Cumbre and Vinchansao Canals. In addition to these two reservoirs, Rodriguez Suy Suy has described four embolsamientos which he has discovered in the Moche Valley (1971).

The area immediately north of the famous Ascope Aqueduct in the Chicama Valley has also been described as a reservoir. Horkheimer describes this area as:

> ... the great reservoir of San José, with a capacity of several hundreds of thousands of cubic meters... (translation of Horkheimer 1961:68).
>
> ... el gran reservorio de San José, con una capacidad de varios centenares de miles de metros cubicos... (Horkheimer 1961:28).

Rodriguez Suy Suy (personal communication) also believes that this area, which he calls La Laguna, functioned as a reservoir. In addition to the large dam-like structure of the Ascope Aqueduct, he points to several canals which appear to empty into the large quebrada behind the aqueduct. He believes that these canals were used to divert excess river discharge into the reservoir.

At Calera de Talambo in the Jequetepeque, Eling (1978:405-406) has described two reservoirs which held approximately 22,000 cubic meters of water. These reservoirs apparently served as a domestic water source to a large archaeological site. In addition, Lostenau (1955) also reports finding water storage features in the Jequetepeque Valley. Unfortunately, I have been unable to obtain a copy of this report to determine if they are the same structures reported by Eling.

If an archaeological structure is to be classified as an impoundment reservoir, it must have certain features and meet certain hydraulic criteria. If these criteria are met, it is possible not only to say with certainty whether or not a given structure could have served as an impoundment reservoir, but also if it did, to define the limits of its capacity.

Care must be exercised in the classification of an archaeological feature as a water storage facility. The construction of earthen aqueducts across quebradas was a common practice during the prehistoric period on the North Coast. The primary function of these structures was to convey irrigation water from one side of a quebrada to the other while maintaining the highest possible elevation over the shortest

possible distance. By their nature, however, these structure also function to dam the quebradas they cross in such a way that the upslope side has the appearance of an impoundment reservoir.

Before these structures can safely be classified as intentional water storage facilities, however, they must meet several additional criteria. Structures intended to provide a water supply as a source for domestic use need only have a closed basin and a water source. These two features must, of course, meet certain hydraulic criteria. If, for example, the actual impoundment structure was of insufficient strength to withstand the hydrostatic forces imposed on it by the impounded water, it would fail. Additionally, if the reservoir basis was highly permeable, large quantities of water would be lost to seepage.

Structures intended to function as storage and redistribution facilities must have an additional feature, an outlet. If water was to be discharged into canals for distribution to agricultural fields, some form of controlled outlet must be an integral part of the reservoir system. Lacking a water lifting technology, the prehistoric populations of the North Coast were limited to two possible alternatives: a spillway, or a conduit.

The spillway is the technologically simpler of the two, but suffers from two major drawbacks. First, the amount of water which can be released from a reservoir through a spillway is limited to that amount which can be pooled above the elevation of the spillway crest. Secondly, the regulation of flow over a spillway could not have been

easily accomplished with the technology available to the prehistoric inhabitants of coastal Peru.

Flow over a spillway can be regulated in one of two ways. Controlling the amount of water flowing into the reservoir in order to maintain a water level higher than the crest elevation of the spillway is obviously not a viable alternative for a storage reservoir. Alternatively, by lowering the crest elevation, more water can be removed from the reservoir. Unless, however, some means is available to do so mechanically through the use of a gate, it would be necessary to dismantle a section of the impoundment structure to accomplish this end. No evidence has yet been found to indicate that the necessary gate technology was available on the prehistoric North Coast. Lacking this technology, the only alternative is to disassemble a portion of the impoundment structure. Even if a society were capable of sustaining the large annual expense of dismantling and reconstructing an impoundment structure, there would be insufficient control over the reservoir discharge to make this an acceptable alternative for controlled irrigation.

The second alternative means of releasing water from an impoundment reservoir is through a conduit extending through the impoundment structure. Conduits have the advantage that they can be placed such that they can completely drain a reservoir. They are, however, subjected to tremendous hydraulic forces in direct proportion to the depth of water at their intake. The materials of which a conduit is constructed must be able to withstand high pressures and

velocities, or it will fail and most likely destroy the impoundment structure, as well. With the construction materials available, it is virtually certain that the prehistoric people of the coast could not have constructed a conduit capable of sustaining the forces to which it would be subjected. For example, if a conduit 1 meter in diameter were placed through the Ascope Aqueduct in order to drain a reservoir only 5 meters deep, the pressure on a gate 1 meter square would be 5,000 kilograms (1024.25 lbs. per square foot). The velocity attained in the conduit would certainly exceed the strength of any materials available for its construction during the prehistoric period.

In light of this brief discussion, it appears that short of manually removing the water from the reservoirs in containers, the technology was not available to construct the necessary water control structures to redistribute water from a storage facility. The hypothesis then, that archaeological structures resembling reservoirs were used to store and redistribute excess irrigation water does not hold up. That is not to say, however, that these structures were never used to store water for domestic purposes. Such structures do not require the use of the controlled outlets which seem to have been beyond the technological capabilities of the prehistoric coastal populations. Even this hypothesis, however, should be subjected to a more rigorous evaluation in light of the hydraulic criteria mentioned above.

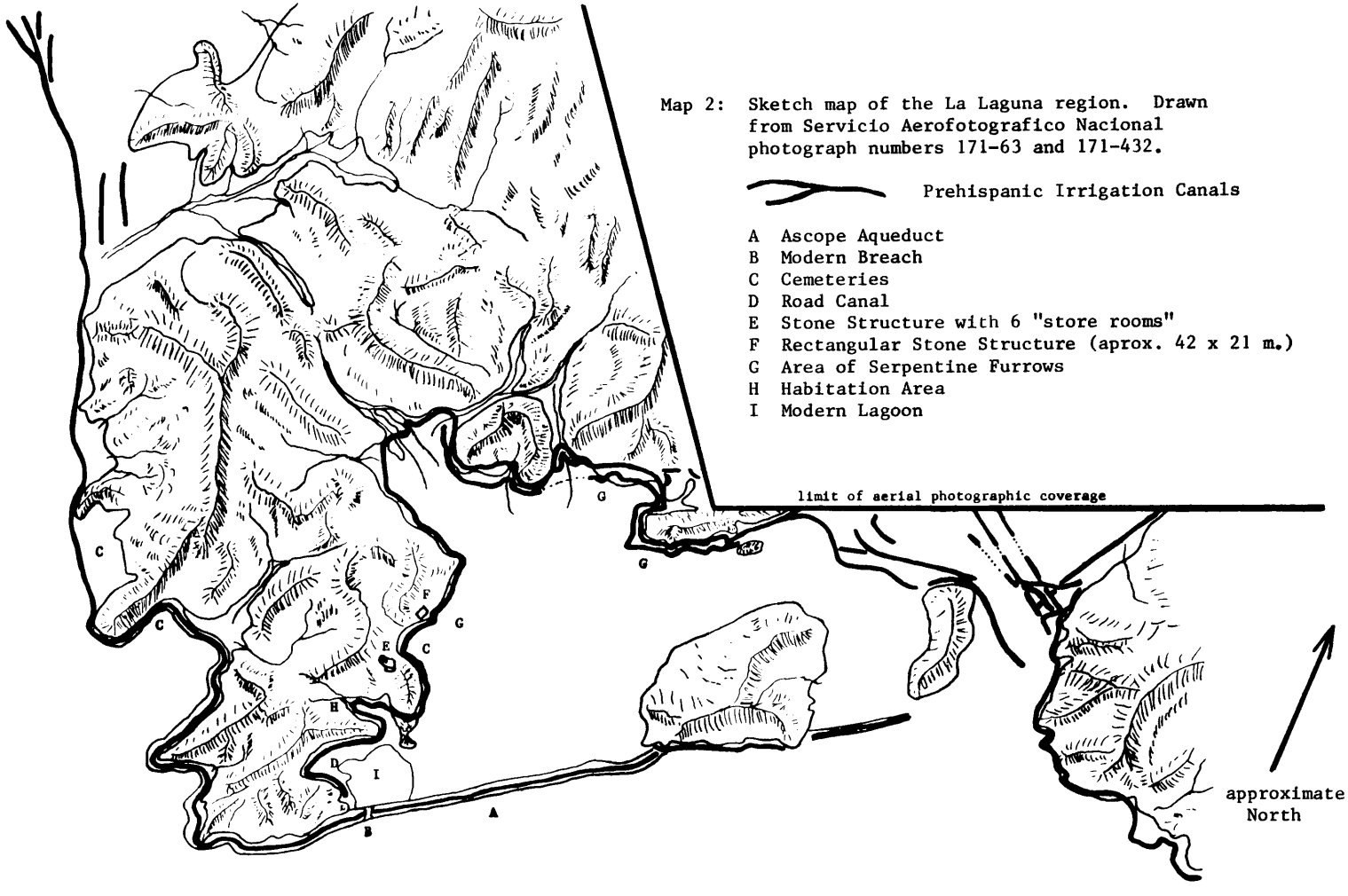
A survey of the La Laguna region by Margaret Kluge, Joel Rabinowitz, and myself failed to find any indication of the water

control structures necessary to redistribute water impounded behind the Ascope Aqueduct. I would even hesitate to state that this region ever formed an intentional impoundment facility for domestic use. Before giving my reasons for this belief, it is necessary to provide a brief description of the area in question by way of background.

The La Laguna region is located on the north bank of the Chicama Valley, approximately 2 kilometers west of the town of Ascope. This area encompasses about 4.75 square kilometers and includes not only canals and other agricultural features, but also population areas, public buildings, walls, and cemetaries (see Map 2).

The most obvious archaeological feature of this region is the famous Ascope Aqueduct. Rough measurements indicate that it is approximately 1.2 kilometers long, 12 to 23 meters high (east and west ends, respectively), and is trapezoidal in cross-section with a base width of from 30 to 40 meters. Observations and rough measurements indicate that the up-slope (north) side of the aqueduct has undergone some deposition due to the damming effect of the aqueduct. The result is that the land surface of the north side of the aqueduct is noticeably higher in elevation than the land surface of the south side.

Approximately 90 meters from the western end of the aqueduct is a modern breach measuring about 23 meters wide. According to informants, this breach dates to the 1925 El Niño and was either cut by personnel from the Casa Grande hacienda to release the impounded water or was caused directly by the impounded water. The examination of this breach indicates that the aqueduct was built in several stages prior



Map 2: Sketch map of the La Laguna region. Drawn from Servicio Aerofotografico Nacional photograph numbers 171-63 and 171-432.

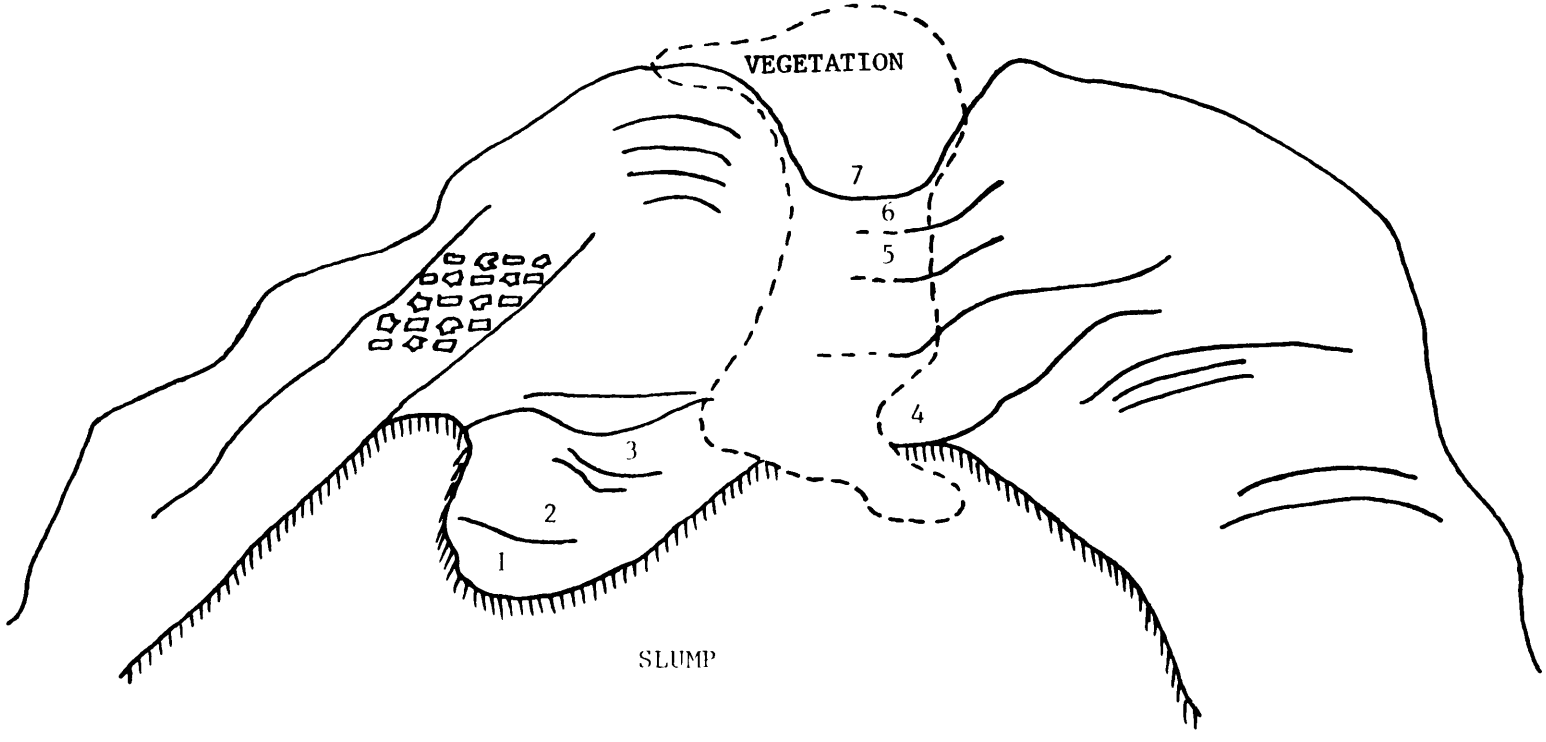
Prehispanic Irrigation Canals

A Ascope Aqueduct
B Modern Breach
C Cemeteries
D Road Canal
E Stone Structure with 6 "store rooms"
F Rectangular Stone Structure (aprox. 42 x 21 m.)
G Area of Serpentine Furrows
H Habitation Area
I Modern Lagoon

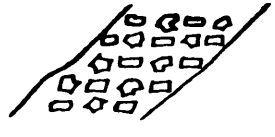
to reaching its present configuration. Buried channels, side slopes, and retaining walls suggest that it was rebuilt several times, presumably to raise its elevation in order to bring additional land under cultivation in the Pampa de Mocán (see Fig. 8).

In addition to the aqueduct canal, another large canal skirts the flanks of the cerros to the north and west of the aqueduct. We have called this canal the Road/Canal because of the obvious dual function it served in connecting the numerous structures and population areas located along and above its banks. This canal presumably represents an earlier version of the aqueduct canal which was abandoned when the aqueduct was built to the same or a higher elevation. The southwesternmost part of this canal may, in fact, even have served as a source of raw materials from which part of the aqueduct was built. This part of the canal was either never completed or was intentionally destroyed. The possibility that the canal was never completed seems unlikely in light of the water-laid sediments found in the channels exposed by erosion.

Other important features include several canals which have been excavated into the alluvium of the large quebrada behind Cerro Ascope. These canals now end in the quebrada channel which discharges into the area behind the Ascope Aqueduct. As I mentioned above, Rodriguez Suy Suy has proposed that they served as the water source from which the reservoir was filled. Other features relevant to this discussion include a cemetary and several areas of prehistoric fields located within the presumed reservoir basin. While most of the area



1,2,3...7 - Areas exhibiting water deposited sediments indicative of canal channels.



Area of stone and adobe construction.

Figure 8. Sketch profile of the east face of the breach in the Ascope Aqueduct.

immediately behind the aqueduct is presently under cultivation, areas of prehistoric fields can still be found bordering the modern fields. All of the fields located by our survey were directly associated with the older Road/Canal.

The hypothesis that this region functioned as an impoundment reservoir to store and distribute excess river discharge is not supported by the presence of these features. The absence of any indications of spillways or conduits through or near the Ascope Aqueduct would indicate that removal of water impounded behind the aqueduct could only have been accomplished manually. An alternative explanation can also be offered for the canals, suggested to have served to fill the reservoir. At the present time, at least five canals appear to empty into the quebrada behind the aqueduct. On close examination, faint remnants of small aqueducts can be seen to cross the quebrada floor. These remnants seem to represent the vestiges of aqueduct structures which have been all but destroyed by runoff from the El Niño rains. The remnants of these structures indicate that the canals now ending in the quebrada were connected to the eastern end of the Road/Canal. These canals can now be seen to represent only a part of an older canal system which, prior to the construction of the aqueduct, was forced to follow the rugged contours of the cerro flanks. The fact that so many canals appear to "end" in this area can be taken to illustrate the tremendous investment which was made in order to cultivate areas long distances from the river.

It is probable that only one of these canals functioned at any

given time. Some, in fact, may represent attempts to raise the elevation of the entire system. The presence of unconnected parallel sections of canals, discovered near the eastern end of the Road/Canal, indicates that adjustments or reconstructions of this canal were also undertaken. A careful comparison of channel bed elevations and stratigraphic cuts is necessary before it will be possible to completely understand the profusion of canals and rebuilding which occurred in the La Laguna region. It is possible, perhaps even probable, that this area served as an unintentional embolsamiento which retained excess irrigation water as it does today. If this was the case, then the local population would have had a readily available source of domestic water. A part of this area may even have been intentionally flooded for this reason, but it could not have functioned to redistribute irrigation water.

Excavated Fields and Drainage/Irrigation

Three additional methods of agricultural water control were practiced during the prehistoric period on the North Coast: mahamaes/sunken fields (Moseley 1969; Parsons 1968; Parsons and Psuty 1975; Rowe 1969; West n.d., 1978, 1979), sangrias/ridged fields (Rodriguez Suy Suy, personal communication; West n.d.), and canalization of springs (Farrington 1974:91; Rodriguez Suy Suy 1971). Each of these techniques was designed to exploit the large reservoir of subsurface water available in the lower valleys. Lacking the pump technology necessary to fully exploit this resource, the utilization of subsurface water was restricted to areas where the water table was at or near the

surface.

Mahamaes cultivation consists of fields excavated to just above the surface of the water table. In this way, water was supplied directly to the root zone of the cultigens by the artificially shallow water table. Recent work by West (n.d.) in the Viru Valley has shown that this type of cultivation can be practiced on many different scales, from shallow 1 x 1 meter individual plots to large, deeply excavated fields covering more than 10,000 square meters.

A major difficulty encountered in the prolonged utilization of sunken fields is their tendency toward soil salinization. This problem appears to have been partially overcome in two ways during the prehistoric period: by actually removing the salinated soil, and by applying a leaf mulch to retard evaporation and slow the accumulation of salts within the soil profile. The use of the first technique has been documented by Ford and Willey (1949:26) who report artificial accumulations of salinated soil in and around excavated fields in the Viru Valley. The second technique has been documented for the colonial period on the South Coast. However, a remark made by Cobo and quoted in Rowe (1969:323) seems to indicate that leaf mulching was probably introduced to the Spaniards by the indigenous peoples:

> In sum, they were such excellent cultivators of their vegetables and plants, and with long experience had attained such knowledge of agriculture, that we have learned from them the entire method of planting and cultivating their crops and much contributing to the good care of our own, such as the procedure of guanoing or fertilizing the plantings in some areas, which is very peculiar and different

> from the way it is done in Spain, and other similar practices (Cobo lib. 14, cap. VIII; 1956, Vol. 92:251, as quoted in Rowe 1969: 323).

With continued research, it would not be surprising to find evidence of this technique on the North Coast.

Precise dating of mahamaes is difficult, but associations and limited testing on the North Coast (Parsons 1968; Moseley 1969; Farrington 1974; West n.d., 1979) indicate a long period of use extending from the beginning of the Early Intermediate Period to at least the late prehistoric. Mahamaes are found in the lower Chicama Valley, but their extent and associations have not been described. In a following chapter, I will describe their distribution and associations as they can be determined from aerial photographs and previous archaeological surveys.

Sangrias/ridged fields represent an adaptation to areas in the lower valleys where the water table is near enough to the surface that some type of drainage is necessary for the area to be efficiently exploited. West (n.d.) has described this type of cultivation in the Viru Valley and indicates that prehistoric sangrias are presently being recultivated by the modern inhabitants. Much the same thing is occurring in the Chicama Valley where it has been recorded by Rodriguez Suy Suy (personal communication). Unfortunately, no estimate can yet be made as to the exact temporal placement, extent or productive importance of this type of cultivation.

The canalization of springs has been very briefly described by

Farrington (1974:91), Kosok (1965:70, fig. 24), and Rodriguez Suy Suy (1971) for the Moche Valley. The Pongo Chongo Canal in the middle portion of the Chicama Valley is described by Netherly (1977:82) as draining a natural upwelling of groundwater. Unfortunately, she gives no additional information.

This section has dealt, in general, with the wide range of agricultural water control techniques utilized by the late prehistoric North Coast populations. I have attempted, in the case of canal irrigation, to briefly outline the physical parameters important to the design and maintenance of canal systems. In the following chapter, I will discuss two specific canal systems in the Chicama Valley for which data regarding these parameters are available. Before undertaking such a discussion, however, a brief mention should be made of the agricultural implements used during the late prehistoric period.

AGRICULTURAL IMPLEMENTS

The practice of large-scale irrigated agriculture on the North Coast required the construction and maintenance of large and complex irrigation systems. Many artifacts described as agricultural implements have been recovered from the North Coast. These implements probably played an important role in the construction and maintenance of the irrigation systems, as well as for actual cultivation purposes. It is likely that some implement specialization occurred concurrently with the development of increasingly sophisticated irrigation and agricultural technologies. The many forms of implements illustrated in the available literature tentatively support this hypothesis.

In an attempt to define the extent and significance of the various implements, a literature search was made. Regrettably, agricultural implements are seldom reported and less often illustrated. Even among those implements illustrated, the vast majority appear to have been recovered from uncontrolled excavations with the result that temporal, spatial, and cultural associations are unknown or inferred only on the basis of stylistic characteristics.

However, artifacts described as agricultural implements have, in at least two cases, been recovered from large caches or offerings. Lechtman (1976) briefly describes these two cases where large numbers of copper/bronze implement tips were recovered:

> According to the report of a <u>huaquero</u> (pot hunter) who dug up hundreds of these in one of the large burial mounds at Chan Chan in 1953 (personal communication of Cristobal Campana, Director of

> the Casa de la Cultura, Trujillo), they were found together, as a distinct category of goods, and separate from maiz, frijoles, semilla (maize, beans, seeds) and large jars of flour, all of which were similarly buried separately and in large quantity (Lechtman 1976:3, footnote 10).

Unfortunately, no systematic study has been carried out on these caches or other agricultural implements from the North Coast. At the present time, it is therefore only possible to briefly describe several examples, to offer a few preliminary interpretations, and to suggest avenues of future research.

The most frequently described agricultural implements from the North Coast are the copper/bronze blades assumed to have been tips for digging sticks. These blades occur in several different forms, most often with a socket into which a wooden handle was inserted (see Fig. 9). Unfortunately, the relationship between the various forms and their intended function is virtually unknown due to the lack of comprehensive studies.

Lechtman (n.d.) questions whether many of the copper/bronze objects described as agricultural implements were ever used or intended for use:

> Many I have seen were obviously never used nor were they intended for use. Some of the presumed agricultural implements are much too heavy to have been functional as tools. Others are cast with relief decorations of serpents or other designs on one side. Still others are miscast or were cast almost as ingots, in spite of their hoe-like shape, with one pronounced concave surface indicating that the metal was probably cast into a flat one-piece mould open at the top. The distinctive feature of all these objects, whether they were used or not,

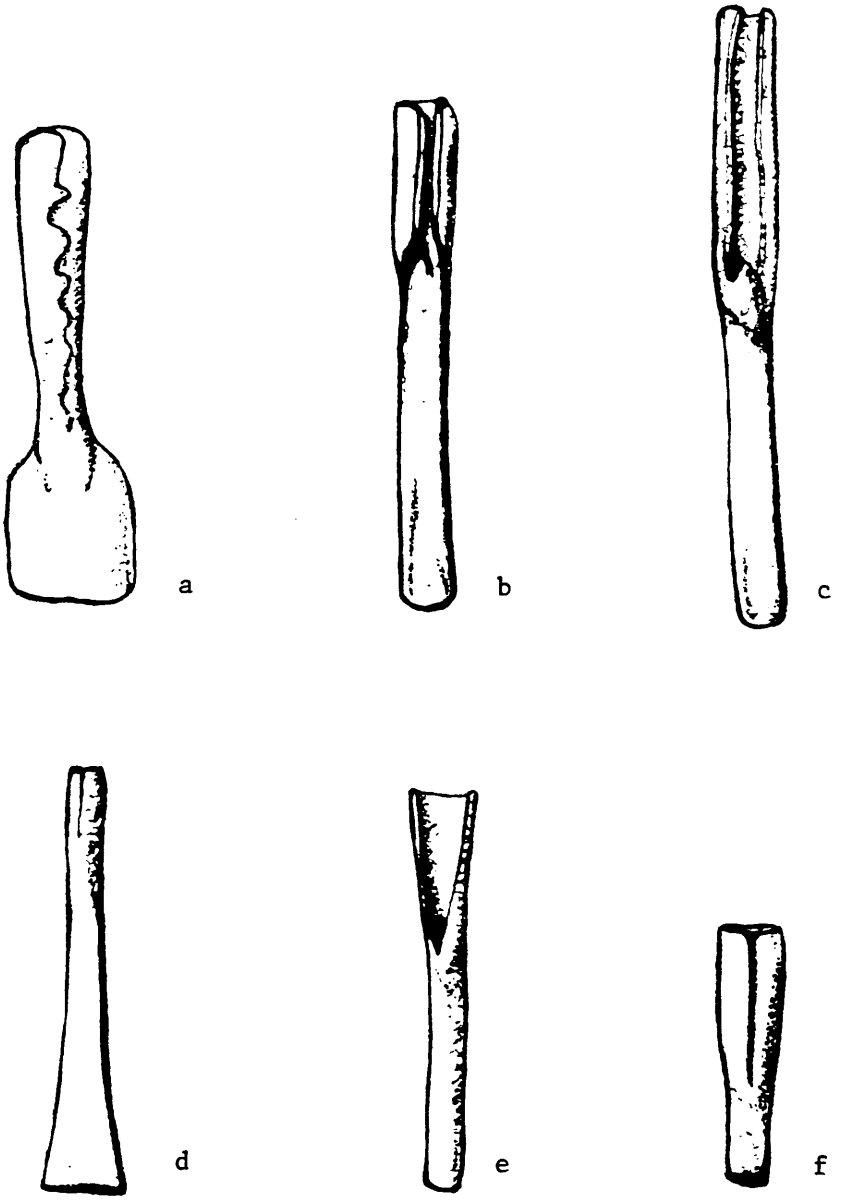


Figure 9 . Copper/bronze digging stick tips. Drawn from Lechtman (1976:figures 3 and 4). a. Chan Chan, Peru. Collection of the Museo de Arqueologia, Universidad Nacional de Trujillo. b-f. Lambayeque Valley, Peru. Collection of the Museo Arqueologico Burning, Lambayeque.

> is the amount of metal they contain. More than anything else, they appear to be "depositories" or "concentrators" of metal. It seems clear from their weight, their burial in large numbers, the unfinished quality of some, the ingot-like quality of others, that the bronze metal itself was considered of value and was amassed. Perhaps it indicated wealth or status, perhaps it had other associations (Lechtman n.d.).

The occurrence of these implements in large caches, as was noted above, seems to support the valued nature of these objects. Lechtman (n.d.) proposes that their value is derived from the value of the metal (copper/bronze) which is concentrated in these implements. This argument is not consistent with the relative values traditionally associated with gold, silver, and copper from as early as the Early Horizon (Lechtman n.d.).

The forms into which the various metals were worked traditionally have been used as an indication of the relative value placed upon the metal itself. Gold and silver objects, or objects with the appearance of gold or silver (gilded or surface enriched alloys), are confined exclusively to ritual or status items throughout Andean prehistory from the Early Horizon to the Spanish Conquest.

As early as the Gallinazo (early Early Intermediate Period), copper was used for utilitarian items such as the atlatl hook and copper rivets recovered by Strong and Evans (1952) in the Viru Valley. Copper and, possibly later on, arsenic bronze was used primarily for ritual or status items only during the Early Intermediate Period. Possibly beginning with the Middle Horizon, and certainly by the Late

Intermediate, intentional arsenic bronze was produced on the North Coast (Caley 1973; Lechtman n.d.). During the Late Intermediate Period, arsenic bronze is found primarily in the form of utilitarian items. The implication that bronze technology was developed and/or adapted specifically for utilitarian purposes is intriguing, if as yet untested.

While substantial quantities of a limited resource (copper/bronze) were concentrated in agricultural implements, it seems more likely that their value was a function of their use. Copper/bronze tipped agricultural implements would seem to offer distinct advantages over unshod implements in terms of efficiency and useful life. The use of metal implements may also have improved agricultural production by allowing the incorporation of previously uncultivated land (Farrington 1974), and through more efficient cultivation.

The concention of large numbers of copper/bronze agricultural implements in caches or offerings may also be indicative or symbolic of social and/or political control. The centralized control of agricultural produce has been documented for the late prehistoric period by the occurrence of storage and redistribution facilities within Elite Centers. Similarly, hoards or offerings of copper/bronze agricultural implements may suggest a high degree of centralized control of metal agricultural implements.

It is interesting to note that although copper/bronze occurs primarily in utilitarian forms during the Late Intermediate Period, it is still a relatively rare commodity. The control of the manufacture

and distribution of such a commodity as metal agricultural implements might then serve as yet another indirect control of the agricultural production so crucial to the Chimu State.

Objection to the use of these implements for agricultural purposes because of their weight (several pounds) does not seem to be valid. A weight of several pounds does not seem to be sufficient reason to disqualify these objects as agricultural implements.

The apparent association of a cache or offering of copper/bronze implements with agricultural products at Chan Chan may also support their value in terms of agricultural production (Lechtman 1976). A wear pattern analysis of the numerous metal implements recovered from caches on the North Coast would prove to be very valuable in answering some of these problems and in resolving the interpretive differences described above.

The taclla, or foot plow, is a distinctly Andean agricultural implement, the presence of which on the coast has not been conclusively demonstrated. Donkin (1970, 1979) notes that while the taclla is represented in Chimu (more specifically, Chimu-Inca) ceramics:

> There is, however, no reason to believe that the taclla was used on the north coast of Peru. The models, in this respect, are comparable to the Mochica "potato pots" of the same region, for both the taclla and the potato belong to the highland (Donkin 1970: 575, footnote 41).

Farrington (1974), on the other hand, believes that the taclla was introduced to the coast by the Inca, and was used to cultivate previously unexploited sections of the lower coastal valleys.

The distinctive thrusting and twisting action of the foot plow would probably produce a unique pattern of wear which should be readily identifiable. In this case, a wear pattern analysis could determine if, and potentially when, the taclla was introduced to the coast.

In general, our understanding of precolumbian Peruvian agricultural implements is conjectural to non-existent. A brief discussion of two types of artifacts described as agricultural implements illustrates the present level of our understanding of this important aspect of prehistoric coastal agriculture.

Most often it is only the metal tips of the implements which are preserved. Some complete digging sticks have been found, however. The most famous example is probably the elaborately carved and inlaid digging stick from the tomb of the "warrior priest" in the Viru Valley (Strong 1947; Strong and Evans 1952).

Many spatulate wooden implements have been described as agricultural implements. Their spatulate form and, in some cases, associated iconographic elements suggest that they may have been intended for use as paddles or oars rather than agricultural implements. Disselhoff (1967:87), for example, illustrates what he calls a raft made of gourd flasks. A man standing on top of the raft carries an oar very similar to many of the implements called "digging sticks." In Bennett (1946:pl. 56), the handle of a wooden "digging stick" is shown upon which is carved a caballito carrying two men, a somewhat out of place decoration for an agricultural implement. This

association is even more curious in light of the evidence presented by Rostworowski (1975) that fishermen did not practice cultivation or even have agricultural land during the late prehistoric period.

Not all spatulate implements appear to be paddles or oars. Spatulate wooden digging sticks have been recovered from the coast. However, the term "digging stick" has been indiscriminately applied to these implements, and a more thorough analysis will be necessary to determine the precise role they played on the coast of Peru.

A South Coast rectangular board form has been described as a "digging board" by Lanning (1967) and Menzel (1977). Lothrop (1932), Heyerdahl (1952), and Edwards (1965) argue that their size and form are most appropriate to their use as center-boards for balsas (log rafts). Iconographic associations and a comparison with early illustrations of balsas supports this contention. Lanning (1967) argues for their use as digging implements on the basis of a wear pattern analysis which he conducted on several museum specimens. Regrettably, he did not describe his analysis, illustrate the wear patterns, or offer alternative explanations for the patterns he observed.

In addition to the digging implements discussed above, there are several smaller agricultural and food processing implements which may shed additional light on late prehistoric agricultural plants and practices. Disselhoff (1967:58-59) illustrates several implements which may have been used for harvesting or food processing (husking, shelling, chopping, etc.). Unfortunately, no descriptions or proveniences are provided, nor could any references to similar implements be found in

the literature. The study of these implements should provide not only specific information on harvesting and plant processing, but also insight into tool/plant assemblages useful in the determination of regional cultigen distributions and use areas within sites.

Two classes of food preparation implements, graters and grinding stones, have much the same potential. Ceramic graters consist of platters or bowls into which deep incisions have been made on the interior surface. It has been suggested that these vessels were used to grate yuca (Kosok 1965:108; Strong and Evans 1952):

> One interesting group of finds consisted of six fragments from large pottery graters. Some of these are over 2 centimeters in thickness and they come from very large low open bowls having deep, rough-edged incisions in various patterns around the upper inner surface. While these may have been used for grating corn or peppers, they seem unnecessarily heavy for such a purpose. Perhaps they were used for grinding yucca or sweet manioc. Fragments of these graters occur fairly frequently throughout those sections of the strata cuts characterized by the Gallinazo period occupation (Strong and Evans 1952:83-84).

Graters have considerable time depth in the Viru Valley, having been found in sites dating as early as the Puerto Moorin Period up to sites of the Estero Period (Bennett 1939; Collier 1955; Ford and Willey 1949; Strong and Evans 1952). They are not limited to the Viru Valley, but occur over much, if not all, of the North Coast (Bennett 1939; Kosok 1965; Schaedel personal communication) and have been reported from the South Coast as well (Kroeber and Strong 1924; Turpin personal communication; Uhle 1924). In our survey of

the Chicama Valley, we also recovered grater fragments from sites containing Gallinazo to Middle Horizon Period ceramics.

At the present time, the exact use and context of ceramic graters is at best only conjectural. Their use as yuca graters seems to be the most likely alternative, however. Ethnohistoric documents describing the use of yuca in the production of chicha may indirectly support this hypothesis (Rostworowski 1975). The production of chicha from yuca must have included the mashing or grating of the roots to facilitate fermentation. Such a process could be readily accomplished using a ceramic grater such as those found on the coast.

Additionally, while showing a wide temporal and spatial distribution along the coast, graters have not been reported from highland sites. This is consistent with their use as yuca graters since yuca seems to be restricted to the lower elevations.

Preliminary research indicates that several forms of graters found on the North Coast may be temporally and/or culturally significant. Excavations by Strong and Evans (1952) in the Viru Valley indicate that graters with an incised pattern of broad nestled "V's" are associated with the Gallinazo Period. Our survey in the Chicama Valley tentatively supports this placement.

Graters, then, may serve not only as indirect support for the significance of yuca to the prehistoric coastal population, but may also prove to be a valuable "index fossil" on the North Coast. Grinding stones, briefly discussed in the chapter on cultigens, may also serve as indirect evidence of the importance of various cultigens

subject to processing by grinding.

None of the implements discussed in this chapter have been subjected to thorough analyses. Complete studies incorporating technological (wear patterns, constituent analyses, replication and experimentation, etc.), archaeological, ethnohistoric, and ethnographic data must be conducted if we are ever to fully understand the technologies of food production and preparation and their implications for the larger cultural systems within which they functioned.

TWO PREHISTORIC IRRIGATION SYSTEMS ON THE NORTH COAST

Of all the prehistoric canals known on the North Coast, probably the two most frequently mentioned in the archaeological literature are the La Cumbre or Chicama-Moche Intervalley Canal and the canal which crosses the famous Ascope Aqueduct. In this chapter, I will discuss each of these canals in light of the physical parameters discussed earlier. In addition, I will outline the implications which can be drawn from these case studies and suggest future avenues of research.

As I noted in an earlier section of this report, the Chicama Valley, during the late prehistoric period, was in a rather unique position. Its immediate proximity to the Chimu capital of Chan Chan strongly implies that most, if not all, of the lower valley was under the direct control and management of the Chimu State. Both the Chicama-Moche canal and the Ascope Canal seem to be the result of state projects designed to bring additional land under cultivation. In both cases, the land to be irrigated lay beyond the earlier limits of cultivation and included more than 1500 hectares (Pampa de Esperanza, 1600 ha; Pampa de Mocan, 5583 ha.).

The information upon which this discussion is based is derived from two primary sources: Kus's work on the Chicama-Moche Canal (Kus 1972, 1978), and field work conducted by the author in association with Margaret J. Kluge and Joel B. Rabinowitz.

As Kus (1972:86-91) has noted, many references have been made to the Chicama-Moche Canal, but few offer much information.

Most merely repeat a reference by Larco-Hoyle (1945:4). Kosok (1965), however, does present several photographs illustrating forms of construction used on the Chicama-Moche Canal. Construction of the canal has variously been attributed to either the Mochica (A.D. 1-800) or the Chimu (A.D. 1100-1476). Radiocarbon dates and ceramic associations described by Kus (1972:123) indicate that the canal was most likely constructed during the Late Middle Horizon or Early Chimu period (A.D. 1000-1100).

The Chicama-Moche Canal is located on the south bank of the Chicama Valley and extends some 74 kilometers from its intake above Sausal to a primary distributary point approximately 10 kilometers north of Chan Chan (Kus 1972:91).

The Ascope Aqueduct is probably the most famous irrigation structure to be found on the North Coast. Unfortunately, while it is frequently discussed in the literature as "...one of the great engineering triumphs of ancient Peru..." (Mason 1957:69), little else besides its dimensions is ever mentioned. While the aqueduct itself is an impressive structure, it represents only a small part of an equally impressive irrigation system. The main canal extends for a distance of approximately 45 kilometers. The Ascope Aqueduct has generally been assigned to the Mochica Period (Bennett and Bird 1964: 116-117; Larco Hoyle 1946:162-163; Lumbreras 1974:102). However, it is my opinion that in its present form, the Ascope Aqueduct and canal should be assigned to the Late Middle Horizon or Chimu period. Recent investigations by Schaedel (personal communication) indicate

that the fields irrigated by this canal in the Pampa de Mocán are associated with structures which are no earlier than the Middle Horizon. Examinations of the breach in the Ascope Aqueduct indicate that it was built in several stages (Kluge, Rabinowitz, and Watson 1976). It is possible that the lower canals exposed in the breach date to the Mochica Period, but additional field work will be necessary to determine if this is the case (see Fig. 8).

Bocatomas

As was noted in the previous chapter, no archaeological examples of bocatomas have been discovered. The bocatoma for the Intervalley Canal is believed to have been at or near the same location as that of the modern acequia Sausal (Kus 1972:92).

The bocatoma of the Ascope Canal has not been checked in the field, but most likely was located between 8 and 10 kilometers east of the modern town of Ascope.

Channels

As would be expected, the construction techniques used on the Intervalley Canal varied in accordance with the type of terrain being crossed. Kus has described the construction of the Intervalley Canal as follows:

> In terms of the construction of the canal itself, the ideal canal channel seems to have been a stone-lined course between three and five meters wide and about two meters deep. If possible, the stone lining of the canal was plastered with some sort of mud or adobe. This type of channel is standard along much of the length of the canal wherever the materials were available. Where large stones were not convenient (a rarity along most of

> the system) the canal bed was nothing more than a channel between two sand or mud banks. In several places, the stones that lined the canal bed seem to have been carried from points several kilometers distant.
>
> Several parts of the Chicama-Moche Canal were built only partly into the ground, with the canal banks raised above ground level by material removed in excavation of the bottom of the channel. In other sections, the canal bed was completely below the level of the surrounding surface. Also, in some places the channel was dug into the side of slopes, with the material removed during excavation forming the outside wall of the canal (Kus 1972: 119).

Several other aspects of canal construction are also mentioned. An elaborate series of buttresses and retaining walls are described by Kus (1972:98) as having been used to support the canal where it was built into the side of a steep slope. Where necessary to maintain the desired slope, the canal was cut into bedrock.

In the statement quoted above, the ideal channel is described as having been stone-lined. In reviewing the descriptions of the thirty-three cuts excavated by Kus (1972:228-248), only five cross-sections revealed stone linings on both banks of the canal. In three cases (cross-sections 23, 30, and 31), the cuts were made in small feeder canals (laterals) and not in the Intervalley Canal itself. Cuts 25 and 29 also showed stone linings on both banks, but were excavations made in tomas (turnouts), structures more subject to erosion than the main canal channel.

The main Intervalley Canal channel seems most often to be lined on only the outside bank or not at all. This conclusion is

based on the figures and descriptions available in Kus (1972), none of which illustrate or describe linings on more than one bank of the main canal.

Two conclusions can be reached with regard to the presence of a lining on the outer bank of the main canal: 1) their primary function was to prevent erosion, or 2) they were primarily to prevent excessive seepage. As I mentioned in my discussion of open channel flow, changes in channel direction alter the distribution of velocities, and hence, erosive force within the channel. The displacement of the higher velocities toward the outside of a curve increases the erosive force acting upon the outer bank. By lining the outer bank, the builders of the Intervalley Canal reduced the probability of canal failure due to erosion.

An alternative, or complementary conclusion, is that the stone and clay lining of the outer bank served to reduce seepage through the unconsolidated fill of which it was constructed. This would not only reduce water loss, but would help to prevent canal failure due to the slumping of banks saturated with water.

By careful examination of both straight and curving sections of the canal, it would be possible to determine if either or both of these conclusions are valid. The occurrence of stone linings on only the outside bank of curved sections would indicate that such linings were primarily a protective measure to prevent erosion. Linings found through the entire length of canal sections have a built-up outer bank would support the conclusion that their primary

function was to control seepage. The nature of the lining, i.e., clay, stone, plastered stone, etc., would also give an indication as to its intended function.

The stone lining of tomas indicates not only a desire for permanence, but also an appreciation of the erosive forces acting upon such structures.

On the basis of evidence presently available, it is not possible to determine the extent of linings present in laterals and field canals, nor to offer completely satisfactory reasons for their occurrence. That such linings served to prevent erosion, possibly due to an increased slope, may be the case, but further work will be necessary before this can be verified.

The minimization of seepage losses may also account for the presence of linings in the smaller canals. In any hierarchically controlled irrigation system, it is to the advantage of each individual user to minimize water loss from that part of the system under his control. However, the administrative authority responsible for the allocation of irrigation water, in this case the Chimu State, need not overly concern itself with such conservation. In the case of a water shortage, the administrative authority merely reallocates the required water to the State lands.

The use of variations in slope and the cross-sectional form of a channel to control flow velocities is an important aspect of canal irrigation. Recent investigations by the Programa Riego Antiguo (Ortloff n.d.; Ortloff, et al. n.d.) indicate that the

channel slope, form (hydraulic radius), and roughness were intentionally manipulated by the prehistoric irrigation engineers in order to control velocity and discharge in the Intervalley Canal. For example, on the basis of the evidence presented by Kus (1972), the form of the canal channel was changed from a trapezoid to a broad parabola in order to reduce the velocities within the canal and prevent erosion where the Intervalley Canal crossed unconsolidated alluvial deposits in the Moche Valley.

By examining the form of the channel in relation to changes in slope, erodibility of the construction material, and changes in direction, it is also possible to determine the extent to which the canal builders used this technique to control deposition and the suspension of sediments, as well as erosion. This evidence indicates that the late prehistoric peoples of the North Coast had a highly sophisticated knowledge of the hydraulics of open channel flow. The discovery and application of several basic hydraulic principles by prehistoric Peruvian peoples predates their discovery and application by the Western world by some five or six hundred years. The investigation of additional canals from a hydraulic perspective should provide important information on the distribution and development of prehistoric Peruvian hydrological engineering.

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The construction of the Ascope Canal differs in several important ways from the Intervalley Canal. Over most of its length, the Ascope Canal crossed much less rugged terrain than did the Intervalley Canal. In many places, the canal was merely excavated into the alluvium. When it became necessary to carry the canal around the side of a cerro, an artificial clay base was constructed over which the canal could run (see Fig. 10B). The Intervalley Canal, on the other hand, is excavated from the slope with the fill forming the outer bank of the canal (see Fig. 10A).

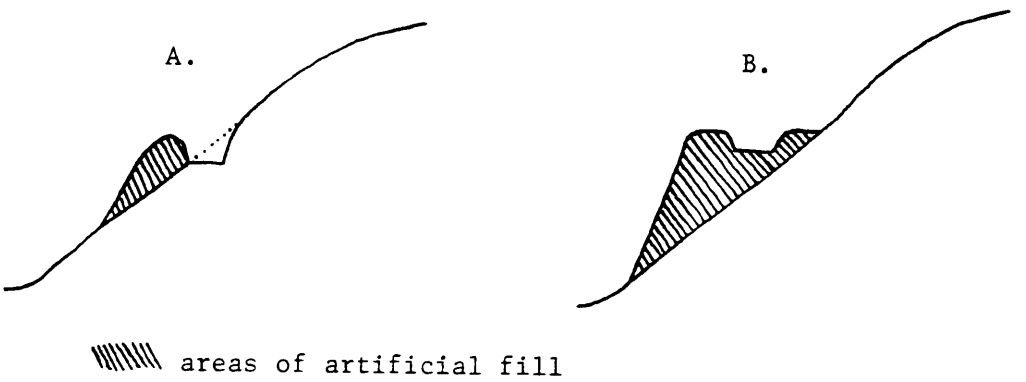

Figure 10. Cross-sections of canals to illustrate construction. A. Intervalley Canal; B. Ascope Canal.

By running the canal on top of a clay embankment, water loss due to seepage would be greatly reduced. In addition, clay is much more resistant to erosion than the sand and gravel underlying the Intervalley Canal. As a result, the channel is unlined, at least in the sections investigated by the author.

A major difficulty is encountered when an attempt is made to

deal with the physical characteristics of the channel of the Ascope Canal. Parts of this canal have been modified and re-used during the first quarter of this century. Evidence of repairs made in concrete indicate that some modification has occurred. While the form of the channel may have been modified, it is unlikely that the slope was greatly altered. To have changed the slope significantly would have necessitated extensive reconstruction of the canal. There is no evidence that such extensive rebuilding occurred during the historic period.

The present cross-sectional form of the modified channel on the Ascope Aqueduct is a trapezoid. Using the Manning equation, discussed in the previous chapter, Orloff (personal communication) calculated that the modified channel had a capacity of from 1.42 cubic meters/second to 3.25 cubic meters/second, with a probable carrying capacity of approximately 2.27 cubic meters/second.

It is interesting to note that the construction of the Road/Canal, discussed earlier, is in some ways more similar to the Intervalley Canal than is the Ascope Canal. The use of stone retaining walls and a channel excavated into the sides of hill slopes are found on both the Road/Canal and the Intervalley Canal, but rarely occur along the Ascope Canal. Clay plastered stone linings also occur on both the Road/Canal and the Intervalley Canal, but were not found on the Ascope Canal. These similarities may be the result of construction techniques adapted to the very rugged terrain over

which both the Intervalley Canal and Road/Canal were constructed. However, if the Road/Canal is older than the Ascope Canal (and the present evidence indicates that this is the case), it is conceivable that the differences are the result of changes in canal construction technology through time. The implication of this supposition is that the Intervalley Canal is also older than the Ascope Canal. This is at best a very tenuous hypothesis, but the implications concerning the exploitation and control of agricultural resources within the "core" or "breadbasket" of the Chimu State are very interesting.

Aqueducts

The need to cross the numerous quebradas which border the lower valley virtually necessitated the construction of aqueducts for both the Intervalley and Ascope Canals. While I do not believe that the part of the quebrada enclosed by the aqueduct served as an intensional reservoir, evidence indicates that it may have been cultivated. In several places along the Ascope Canal, small canals can be found which served to irrigate these up-slope areas. These small canals may be associated with the modern re-use of the Ascope Canal, but they should be investigated further.

Numerous aqueducts of various sizes were constructed along the Intervalley Canal. One of the largest, at the site of Quebrada de Oso, was investigated by Kus (1972). He found several levels of superimposed channels in a cut made across the truncated aqueduct (Kus 1972:246, 248). Unfortunately, the excavation was destroyed during the earthquake of May 31, 1970, before the work on the

profile had been completed. Excavation through a much smaller aqueduct indicates that the banks were built up of layers of gravel and "mud" over an inner stone core (Kus 1972:228-229). Kosok (1965: 106) illustrates an example of the use of retaining walls in the construction of an aqueduct on the Intervalley Canal.

The Ascope Aqueduct and the smaller aqueducts found along the Ascope Canal are constructed primarily of clay or adobe. In some places, stone and/or adobe retaining walls may have been used to stabilize the sides of the aqueducts, but they are much less frequent and extensive than those found along the Intervalley Canal. These walls, however, may have served as much to provide a flat surface for trails or structures as for stabilization. Evidence for structures built on the sides of the Ascope Aqueduct can be seen at several places. The difference in construction materials used for the Intervalley and Ascope Canals may account for the relative absence of extensive retaining walls along the Ascope Aqueduct. Retaining walls, of course, may have been constructed of adobe and have merely become obscured by erosion.

In general, the aqueducts associated with the Ascope Canal are longer and more massive than those of the Intervalley Canal. A possible explanation may be in the different constructional histories of the two canals. The Intervalley Canal seems to represent a single project which, from its inception, was designed to cross the divide between the Chicama and Moche Valleys in order to irrigate the land north of Chan Chan. The Ascope Canal, on the other hand, appears to

have undergone a number of transformations before reaching its final form.

Kosok was of the belief that the Intervalley Canal may have been initially constructed to carry water only to the lower part of the Chicama Valley and was only later extended into the Moche Valley.

> While the canal obviously had been used principally to carry water into the Moche Valley, at least during one period, it had also been used to cultivate land within the Chicama Valley, a fact that became clear to us when we found a number of large branches of the canal that remained within the Chicama Valley itself. Indeed, it is possible that the latter branches had been built before it was decided to extend the canal into the Moche Valley (Kosok 1965:106).

Kus (1972:118-119), however, found no evidence of the large branch canals described by Kosok. I have also been unable to confirm their presence on the basis of aerial photographs. It is possible that Kosok was making reference to the canals at the Quebrada de Oso site. Or he may have been referring to one or more of the numerous incomplete sections of canals located adjacent to the Intervalley Canal. Kus (1972:116-117) mentions that there are several sections of incomplete canals which roughly parallel the main canal. He interprets these canals as evidence that the Intervalley Canal was built in discontinuous sections, some of which, due to inadequate surveying technology, had to be rebuilt in order to attain the proper slope. These sections, in some cases, are quite long and could easily be mistaken for branch canals.

On the basis of channel profiles exposed in erosional cuts

and the location and distributions of canals and fields, it appears that the constructional history of the Ascope Canal is more complex and possibly longer than that of the Intervalley Canal. There are several channels (possibly as many as six) exposed in the upper half of the breach in the Ascope Aqueduct. At least two additional channels have been exposed by an erosional cut through the Road/ Canal. On the basis of these profiles, the Ascope Canal appears to have undergone as many as eight periods of rebuilding. In addition, the distribution of canals and fields in the Pampa de Mocan indicates that the elevation of the main canal was raised at least three times in order to incorporate additional lands.

Turnouts and Drop Structures

Based on the available evidence, turnouts, or tomas, used to remove water from canals for redistribution through laterals or field canals during the late prehistoric period, frequently incorporated a drop sturcture. Drop structures which served as overflows have recently been described for the Intervalley and associated canals in the Pampa Huanchaco (Ortloff n.d.; Ortloff, et al. n.d.).

Kus investigated three tomas associated with the Intervalley Canal, each of which he briefly described. Regrettably, he did not provide any illustrations of these structures.

> Cross Section 25. This was an excavation of a tomo [sic] or spillway that removed water from the feeder canal and directed it into a series of fields to the southwest. This tomo is about 300 meters north of Cross Section 24. The tomo is in the shape of a "Y," with a wide upper section (3 meters) and a narrow lower

> channel (.4 meter). It seems likely that the upper channel did not carry water, but rather was a platform from which the control of water was managed. Both levels were constructed of stone, with neat walls and a relatively smooth surface for the platform. The width of the canal bank, and thus the length of the tomo, is 6 meters. The depth of the lower channel was about .4 meter.
>
> Cross Section 27. This is another tomo located between cross sections 24 and 25. At this tomo the excavation was extended across the entire canal, and since the level of the water in the canal could have been no higher than the top of the tomo, this point gives a good indication as to the maximum water level in this portion of the canal. At this point, the feeder canal was about 4.5 meters wide and 1 meter deep. The tomo was about 1 meter deep, also, .5 meter wide, and 7.5 meters long. Midway through the tomo a pile of three large stones probably served as a barrier to keep water from passing through to the fields beyond the tomo.
>
> Cross Section 29. This was a small and extremely narrow tomo about 25 meters north of Cross Section 28. It was almost exactly 1 meter deep and about .3 meter wide. Both walls of the tomo were lined with stone. The tomo permitted water to be removed and directed to a single canal that lead [sic] to a set of irrigated fields to the west (Kus 1972:244-245).

The use of a stone lining to prevent erosion and to better insure permanence was discussed above. Several other important characteristics, however, are not discussed in these descriptions. In general, it is not clear what the relationship is between the diversion channel and the main canal channel. Answers to the following questions would allow us to more fully understand the engineering and construction technology which went into the building of the Chimu irrigation system: What is the slope of the toma channel in

relation to that of the main canal? Does the diversion channel extend all the way to the bottom of the main channel? At what angle does the toma channel leave the main canal channel?

The turnouts located along the Ascope Canal were smaller than those described by Kus. Several small turnouts were noted along the Ascope Aqueduct and the main canal as it extended from the west end of the aqueduct around the side of a cerro to the west and north. Some or all of these structures may be associated with the modern re-use of the Ascope Canal. Each of the turnouts was unlined, having been merely excavated through the bank of the canal. In all cases, the intake of the diversion channel did not extend to the bottom of the main canal channel and entered the main channel at an angle pointing downstream (see Fig. 11B).

These two characteristics seem to support the contention that temporary dams were used to divert water into the tomas. By constructing the toma so that the bottom of the diversion canal is normally above the surface of the water level in the channel, it would not be necessary to seal the diversion channel. By simply removing the temporary dam, the water level would drop below the intake of the diversion channel.

By angling the intake downstream, the toma is less subject to erosion. When the water level in the main channel exceeds the bottom level of the turnout intake, the velocity of the water enter- the diversion channel was greatly reduced by the downstream intake (see Fig. 11B).

More and larger turnouts are certain to be found in the field systems in the Pampa de Mocán, but we did not investigate this region.

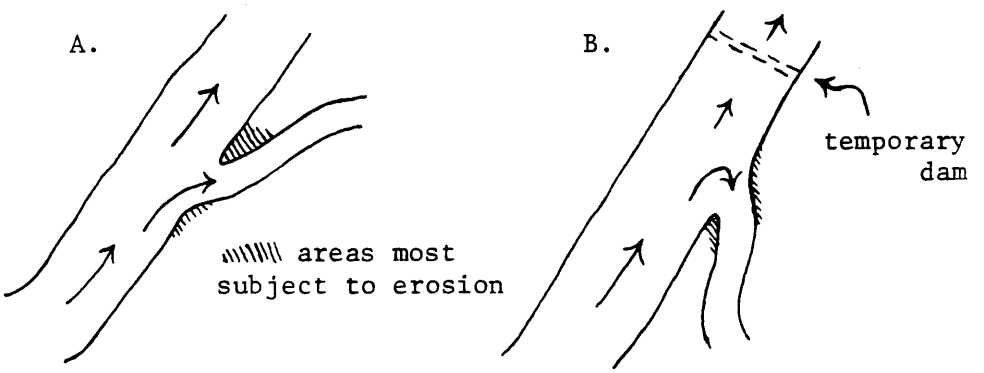

Figure 11. Canal turnouts (tomas). A. - reconstruction of general form of turnouts described by Kus (1972). B. - form of small turnouts located along Ascope Canal.

Drop structures have recently been described along the Intervalley Canal and in the canals which irrigated the Pampa Huanchaco (Ortloff n.d.; Ortloff, et al. n.d.). These structures are located at crucial points in the canal system and serve as overflows to prevent the channel from being damaged or destroyed by excess discharge. Drop structures were located along the Intervalley Canal just before the large aqueduct crossing the Quebrada de Oso. Such a placement would serve to protect the aqueduct from large flows which might damage or destroy it. These structures were associated with channel modifications designed to produce the optimal flow across the aqueduct in order to minimize both construction and maintenance costs.

Drop structures associated with the Pampa Huanchaco field systems apparently served much the same function. These structures,

however, were intended to protect an entire system of aqueducts, canals, and fields (Ortloff, et al. n.d.). The use of drop structures in this fashion illustrates some important points. Prehistoric irrigation engineers obviously recognized the necessity of protecting irrigation canals and structures from excessive flows and used drop structures as a means of automatically diverting excess flows. Drop structures also appear to have performed the additional function of maximizing channel flows by automatically removing water in excess of the design discharge. The need to provide a means of rapidly and automatically removing excess flow suggests that an efficient means of rapidly reducing the canals intake flow was not available.

Field Systems

Agricultural field patterns reflect human behavior as it is conditioned by cultural perceptions of several physical variables. By defining the relationships which exist between the physical variables and the variations exhibited in agricultural field patterns, it becomes possible to better understand the perceptions and behavior manifested in these patterns.

Three groups of physical variables seem to be the most likely to have influenced prehistoric field patterns: 1) soil characteristics such as field capacity (ability to store water), drainage, and fertility, 2) topographic characteristics such as slope and land conformation, and 3) climatic characteristics such as prevailing winds and seasonal variations in temperature, cloud cover, and precipitation. The cultural selection of cultigens also imposes

additional constraints on agricultural field systems. The varying water requirements of crops grown within a single system will require adjustments which may be reflected in field patterns. Furrow patterns, for example, may be designed to pool water around those crops requiring large quantities of water, or their width and spacing can be adjusted to deliver only a small amount of irrigation water.

Socio-cultural variables also influence agricultural field patterns. Settlement patterns and land ownership, for example, may account for the occurrence of small "plot clusters" versus large blocks of uninterrupted fields.

The most obvious aspect of a prehistoric, North Coast agricultural field system is the pattern of furrows and borders defining individual plots or fields. When reference is made to these systems, which is seldom, it frequently consists of nothing more than a photograph and very short description of serpentine furrows or checks.

As I noted above, our study of the Ascope Canal did not include the largest area of fields found in the Pampa de Mocán. It is not possible, therefore, to discuss in detail fields associated with the Ascope Canal. Where appropriate, however, examples of fields discovered along the central portion of the canal will be used for supportive or illustrative purposes.

Only one study has been conducted which incorporated an analysis of field systems. In his study of selected aspects of Chimu agriculture, Kus (1972) discusses the field patterns found in

association with the Intervalley Canal, particularly those at the site of Quebrada de Oso. In this study, six "furrow" patterns were defined, as well as several combinations of patterns. Since this is the only discussion of field patterns available for the North Coast, I will briefly outline it here:

Type One - Straight furrows are the most common furrow pattern at the Quebrada de Oso site, covering about 66 percent of the irrigated area. Most straight furrows are aligned parallel to the slope of the fields which averages about 2.5 percent (Kus 1972:168-170). In interviews with peasant farmers in the lower Chicama Valley, Kus found that in modern hand-cultivated fields, straight furrows are desirable for the staple crops of maize, beans, camote and yuca:

> If anything, then, the contemporary ethnographic information would seem to indicate that such staple crops as maize, beans, sweet potatoes, and manioc were planted in the largest amounts at the Quebrada de Oso site, although this is, at best, a tenuous assumption (Kus: 1972:171).

Type Two - The interrupted straight furrow is similar to the straight furrow pattern except that the furrows are much shorter and most often run across rather than down the slope. The average slope of the fields is approximately 2.3 percent. No modern examples of this type were found in the Chicama Valley, nor were the peasant farmers familiar with such a pattern:

> The interrupted straight furrow seems to have been a modification of the straight furrow pattern used to 'pool' water in across-slope

> situations -- perhaps for crops that required especially deep watering or especially heavy watering. This idea is reinforced by the fact that the majority of fields of Type Two (16 out of 28) were located at the down-slope end of field systems, indicating that they may well have been used to trap any remaining water that came through the field system (Kus 1972:174).

Type Three - Furrows in this pattern have the form of an "E" with water entering each furrow group along the vertical axis and becoming pooled in the horizontal "arms" of the "E." The average slope of this type of furrow is almost identical to that of Types One and Two (2.3 percent). Approximately one-third of the Type Three fields ran across the slope. At the Quebrada de Oso site, Type Three fields were heavily concentrated in a single part of the site:

> Since no modern farmer was familiar with this type of furrow design, it can only be suggested that perhaps this was a pattern used for some water-intensive crop which required the pooling of water. The existence of relatively wide furrows in this field type suggests again that this furrow design may have been used for different types of crops than furrow patterns one and two. Finally, the clustering of "E" pattern fields also suggests that this pattern was used for crops that were different from those raised in the straight or interrupted straight furrows (Kus 1972:176).

Type Four - This pattern is the serpentine furrow most often illustrated as indicative of prehistoric agriculture on the North Coast. The average width of this type furrow at the Quebrada de Oso site is intermediate between the average widths of Types One and Two and Type Three:

> No significance is placed on the width of the serpentine furrows. These furrows were,

> however, most often found in areas of greater slope; the average slope of the serpentine fields was 3.1 percent as compared to 2.3 to 2.5 percent for the fields of types one through three. It is suggested that serpentine furrows were used in areas of greater slope, regardless of the crop raised in the field. Interviews with peasant farmers in the Chicama Valley located two men with knowledge of the serpentine pattern for furrows; in both cases "sloping land" was volunteered as the reason for making use of this type. Thus a field characteristic, namely slope, rather than a crop seems to be, and have been, the reason for making use of field with a serpentine furrow pattern (Kus 1972:177).

Type Five - The most significant aspect of this type of furrow is the presence of piles of stones scattered throughout the fields. This pattern is very interesting, and in at least three cases, the use of "furrow" type is a misnomer. Three of the fields described by Kus (1972:180) are obviously border-irrigated fields rather than furrow irrigated. The average slope of these fields at the Quebrada de Oso site was 2.7 percent, not significantly different from Types One, Two, or Three:

> Statistically, the Type Five pattern of stone piles is much the same as the other fields, except for the existence of regularly spaced stone piles throughout this pattern (Kus 1972: 180, 182).

None of the peasant farmers interviewed were familiar with this type of field pattern or could offer an explanation of its utility. Kus was also unable to give a satisfactory explanation for its use. He did tentatively suggest, however, that the Type Five fields may have been used for the cultivation of a ground-cover crop which did not require furrows or that the fields were incomplete when they were

abandoned (Kus 1972:182).

Type Six - The sixth type of furrow pattern represents a combination of Types Three and Four, "E"-shaped and serpentine furrows:

> The Type Six furrows typically resembled serpentine furrows in overall pattern, in that water slowly snaked through the furrow system, but they also resembled the "E" pattern in that each loop of the serpentine furrow had two or three dead-end furrows, identical in pattern to Type Three (Kus 1972: 183).

This type was most similar in overall characteristics to Type Three, with a mean furrow width very close to that of Type Three (1.02 meters to .99 meter) and an average slope of 2.4 percent (versus 2.3 percent for Type Three).

> Most likely the same type crops could have been raised on both field types, although the movement of water would have been slightly more rapid through the Type Six pattern and, therefore, this may indicate some difference in cropping pattern (Kus 1972: 183).

Combinations - Several additional combinations of furrow patterns were found at the Quebrada de Oso site. The total area of the six fields which included these additional combinations was only slightly more than 2 percent, and the fields were not discussed in detail.

> Two such fields were combinations of Types One and Three, and two were combinations of Types Two and Three (Kus 1972:183).

Summary and Discussion

Kus's study of agricultural field patterns on the North Coast

can be said to have broken fertile new ground in our understanding of late prehistoric subsistence. As an initial study, it, of course, suffers from a number of deficiencies, but provides an important framework and impetus for future studies. In this section, I will critically discuss this study with the goal of providing alternative explanations and expanding the framework for future work.

In his analysis of furrow types at Quebrada de Oso, Kus attributed much of the variation between types to differences in cultivation practices due to different crops. While it is logical to assume that crops played an important, if not primary, role in affecting the kind of field pattern used, other alternatives must also be considered. Alternative explanations can be offered for several of the conclusions reached in Kus' analysis.

In the cases of Types Two, Three, and Six, for example, it was suggested that the conformation of furrows was such that water was pooled, possibly for crops requiring especially deep or heavy watering. An equally plausible explanation may be that fields exhibiting these types of furrows occur on soil which is very slowly permeable. In this case, the pooling of water is necessary in order to obtain the required depth of soil moisture.

In the case of Type Five, Kus found it difficult to offer a satisfactory explanation for the stone piles. A possible explanation may be found by examining the nature of the archaeological data represented by prehistoric field and furrow patterns. Agricultural field patterns are the result of a series of human activities

which produce distinctive patterns in the form of furrows and field borders. It seems most logical to assume that agricultural fields are generally abandoned after harvesting. In the case of many crops cultivated and harvested by hand, a minimal amount of disturbance of the ground surface will occur. Hatch (1976:156-163), in his study of the modern peasant farmers in Motupe, Peru, shows that little, if any, disturbance of the ground surface occurs in the hand-harvesting of maize. However, in the case of root crops such as camote and yuca, it is necessary to dig the tubers. In a stony field planted to root crops, it would not seem unreasonable to find concentrations of stones removed during the process of digging tubers. If a field were to be reused for root crops over a period of years, it would definitely be to the advantage of the cultivator to concentrate stones in the uncultivated areas between plants in order to facilitate subsequent planting and harvesting. Fields of this type are not limited to the area irrigated by the Intervalley Canal, but also occur at the site of Ascope Viejo below the Ascope Canal.

The presence of straight (Type One) furrows in a number of the Type Five fields is very interesting, especially in light of the comments made by the modern peasant farmers interviewed by Kus. In these interviews, it was indicated that straight furrows were particularly desirable for staple crops such as maize, beans, camote, and yuca. The available evidence seems then to suggest that Type Five fields represent the post-harvest remains of fields cultivated in root crops.

Additional evidence to support or refute these hypotheses must come from additional field research. In the following short section, I will make several suggestions regarding potentially fruitful directions for continued research.

In order to understand agricultural patterns and knowledge, it is necessary to understand the environmental parameters within which the agricultural system functioned. It is then possible to determine which parameters were recognized by the agriculturalists and to what extent agricultural activities were affected by them. The variables outlined above represent an approximation as to those most likely to be significant to irrigation agriculturalists. This list is not complete and should be modified in relation to the case under consideration. One means by which potentially significant environmental variables can be determined is through ethnographic research on modern traditional cultivators (c.f. Gillin 1947; Hatch 1976; Sabogal 1976).

The soils, topographic, and climatic characteristics listed above are readily measured and, in some cases, may be adequate for an evaluation of prehistoric agricultural patterns and knowledge. Probably the single most important aspect of any analysis of this kind is a complete recording of the patterns and variations found within the field system. By a careful comparison of these patterns and variations with the environmental variables, it is possible to determine whether or not these variables were recognized and manipulated by the prehistoric agriculturalists.

In his analysis of the Quebrada de Oso site, Kus found a strong and consistent correlation of Type Four (serpentine) furrows with areas of increased slope (Kus 1972:177, 185). Similar correlations with other environmental variables may also occur, but were not investigated.

Field and furrow patterns are the result of behavior constrained by the cultivator's perceptions of the environment, cultural tradition, and technology. Cultural traditions and technology which affect agricultural patterning are more difficult to measure than are the environmental variables dealt with up to this point. Once the variability resulting from the manipulation of environmental variables has been defined, the remaining patterns and variations may be attributed to cultural traditions, technology, and idiosyncratic behavior. The cultural tradition of most interest here is whether there is an association between different crops and different field and furrow patterns. The use of pollen and/or phytolith analysis should prove to be very helpful in answering this question. Ethnohistoric and ethnographic research may also shed light on this problem. The effects of technology on field and furrow patterning is not well understood in the prehistoric setting. Research into implement wear patterns and ethnohistoric and ethnographic comparisons should prove to be enlightening, however.

Once the sources of variation and patterning within a prehistoric irrigation system are defined, the archaeologist is on much firmer ground when drawing conclusions regarding the

implications of irrigated agriculture. In addition, it is also possible to better support statements with regard to the relative proportions of different crops cultivated and to begin to draw conclusions concerning carrying capacities. In general, this approach provides the archaeologist with a far better assessment of the societal and cultural implications than does the overly simplistic variable of scale.

PREHISTORIC FIELDS AND LAND USE IN THE LOWER CHICAMA VALLEY

In the previous chapters, I have dealt with late prehistoric agricultural technology in general terms and have used examples from the Chicama Valley to illustrate the nature and complexity of this technology. In the following sections, I will discuss several specific areas and attempt to reconstruct the late prehistoric agricultural exploitation patterns in the lower Chicama Valley. While it is not possible to determine the exact extent and nature of prehistoric exploitation in this part of the valley due to the destruction of archaeological remains by modern agricultural and construction activities, sufficient evidence remains to detect general patterns.

Two of the areas exhibiting prehispanic canals and fields are located on the same prehistoric canal system. The smaller area is located east of the town of Ascope, adjacent to the site of Ascope Viejo (Site #53). This area contains two major canals which irrigated approximately 173 hectares above the limit of modern cultivation. Two types of fields, serpentine furrows (Type 4) and rock piles (Type 6), were found in this area during a short reconnaissance, and it is very likely that additional types will be found with further work. Due to the fact that this area has been badly disturbed by modern agricultural activities, gravel mining, and erosion, it is not possible to determine the relative age of the canals and fields in this area without further fieldwork.

The larger area of canals and fields stretches for more than

17 kilometers to the north of Hacienda Facala. This area encompasses portions of two regions known as the Pampa de San José and the Pampa de Mocán. For the sake of convenience, however, this area will be referred to as the Pampa de Mocán.

The Pampa de Mocán was irrigated by a series of seven roughly parallel major canals which watered an area of approximately 5850 hectares above the limit of modern cultivation. The location and distribution of these canals suggests that they may form a sort of horizontal stratigraphy with the oldest canal being found at the lowest elevation and the youngest at the highest elevation. Since the canals and fields in the Pampa de Mocán are the ultimate end of the Ascope Canal, this system provides a unique opportunity to study the sequence of development of a large irrigation system on the North Coast. By correlating the construction sequences exposed in the Ascope Aqueduct and the Road Canal with the horizontal stratification of canals in Mocán, it should be possible to more fully understand this system.

The fields in the Pampa de Mocán are usually defined by long parallel borders perpendicular to the canals. The presence of furrows, unfortunately, cannot be determined from the available aerial photos and must await further fieldwork. Those fields located in the outwash areas of the large quebradas which enter the Pampa de Mocán tend to be smaller and less regular than those not located in the outwash areas. Some of these fields also contain what appear to be artificial accumulations of stones in piles

within the fields and along the field borders. It is possible, perhaps even likely, that not all 5,583 hectares potentially served by the Mocán canals were cultivated. Several areas of fields, particularly along the northern limits of the highest canals, may have been abandoned prior to their completion.

On the basis of aerial photographic evidence, an estimated 56.9 percent, or 3,330.8 hectares, of the Pampa de Mocán may have been temporarily brought back into production, most likely some time during the first third of the Twentieth Century. The remaining 43.1 percent (2,522.6 hectares), however, seems to have been unaffected by modern agricultural activities. In spite of modern efforts at rehabilitation, the general pattern of the precolumbian canal system appears to have been maintained.

The prehistoric remains in the Pampa de Mocán are of interest for a number of reasons. The size and structure of these remains suggest that they were probably planned, constructed, maintained, and used by, or more likely for, the Chimu State. Only at the highest levels of the hierarchical political structure known to exist during this period (Netherly, n.d.) could sufficient manpower have been mobilized and organized to construct a project of this size.

The structure or layout of this area is also suggestive of high level planning and management. Centralized control and management of agricultural production is most efficiently accomplished

through the use of large-scale extensive units of cultivation, such as are found in the Pampa de Mocán. The fact that such large units occur in this area has some important implications. The presence of extensive regular field patterns suggests that they were carefully planned and constructed on what was virgin soil, rather than imposed upon pre-existing and perhaps less orderly field patterns which would be found in previously cultivated regions. The similarity of canal patterns of seemingly different ages also suggests a continuity of planning authority. This similarity may be more apparent than real, however, since present interpretations can be made only on the basis of aerial photographs. The canals and fields in the Pampa de Mocán seem then, to represent a planned expansion into previously uncultivated lands undertaken by a high level political entity which I believe to have been the Chimu State. In the following sections I will provide additional evidence in support of this contention.

No archaeological remains indicative of a large permanently resident population in, or immediately adjacent to, the Pampa de Mocán have been reported in the literature or are visible on the available aerial photographs. This would seem to suggest that the labor necessary to cultivate such a large area was brought in on a short term basis during periods of peak labor requirements such as planting and harvesting.

The architectural remains which are visible in the Pampa de

Mocán can be roughly grouped into three categories on the basis of their size and configuration as determined from aerial photos. The first category consists of small rectangular structures (approximately 8.75 x 8.70 m) which may have functioned as field houses. Twenty-two such structures have so far been identified.

The second category of architectural remains consists of nineteen larger rectangular enclosures which exhibit no interior features visible on aerial photographs. These structures exhibit a wide range of sizes from 21.75 x 23.55 m to more than 44 x 48 m, and may have served as processing areas for the products grown in the surrounding fields.

The final category contains a wide variety of sites, at least one of which probably predates the Mocán fields. This category includes Sites #56 (Huaca Puckuche), #57, #58, #79, and #80 (see Appendix 5). Each of these sites appears to have functioned as an administrative and/or religious center. Three sites, #57, #58, and #80, seem to be associated with prehispanic roads and may have functioned as administrative centers for the State fields. Huaca Puckuche certainly predates the large-scale agricultural expansion into the Pampa de Mocán throughout most, if not all, of its occupation. Site #79 consists of a large (54.75 x 71.25 m) rectangular enclosure containing what appears to be a samll huaca or burial platform. This structure has been bisected by an irrigation canal (probably modern) which passes through the huaca/burial platform

and a portion of the adjacent structure. Additional fieldwork will be necessary to clarify the relationships between these architectural remains and the prehispanic canals, fields, and roads in the Pampa de Mocán.

The soils in the prehistorically exploited region of the Pampa de Mocán are overwhelmingly dominated by eutric fluvisols which compose 93.52 percent or 5,474.2 hectares with the remaining 6.48 percent (379.5 hectares) being eutric regosols (see Table 13). The fluvisols which are found in this area have been broken down into three use classifications (see Table 13). The largest of these classifications contains flat "irrigated" eutric fluvisols with a use classification of from 1 to 3 (Fe(i)-a 1-3) (see Table 13 and Map 4). This classification represents approximately 49.67 percent of the land in the Pampa de Mocán. The description of 2,907.4 hectares in Mocán as irrigated is somewhat misleading. The vast majority of the soils which are included in this category are presently covered with algarroba forests and are only incidentally irrigated by excess water not used in the irrigation of economic crops. Of the 2,907.4 hectares classified as irrigated, only about 690.5 hectares (23.75 percent) are actually producing an economic crop (sugar cane). It is very interesting to note that the area which has been classified as useful for intensive agriculture (use classes 1-3, see Table 4) closely corresponds to the area which appears to have undergone modern attempts at rehabilitation.

The second largest classification of soils in the

Table 13. Summary of soil types in areas exhibiting evidence of prehistoric agricultural exploitation.

	Eutric Fluvisols [1]														Eutric Regosols								Gleyic Solonchaks		Desertic Lithosols		
	Fe(i)-a 1-3		Fe(un)-a 3		Fe(un)-a 4		Fe(un)-a 8		Fe(un)-a 4&8		Fe(un)-ab 4&8		Fe(un)-c 8		Re-a 4		Re-a 8		Re-a 4&8		Re-Sg-a 8		Sg-a 4&8		Ld-c 8/7		Total
	area[2] (ha.)	% area	area (ha.)	% area	area (ha.)	% area	area (ha.)	% area	area (ha.)	% area	area (ha.)	% area	area (ha.)	% area	area (ha.)	% area	area (ha.)	% area	area (ha.)	% area	area (ha.)	% area	area (ha.)	% area	area (ha.)	% area	area (ha.)
Ascope Viejo % soil	0.0		0.0		122.2 4.12	70.6	0.0		0.0		27.1 100.0	15.63					0.0		0.0		0.0		0.0		23.8 27.11	13.76	173.1 1.42
Pampa de Mocan % soil	2907.4 63.80	49.67	0.0		2414.1 81.35	41.24	0.0		152.7 75.33	2.61	0.0		0.0		0.0		379.5 36.76	6.48	0.0		0.0		0.0		0.0		5853.4 48.07
Pampa de Paijan % soil	74.2 1.63	10.88	434.6 46.81	63.75	0.0		0.0		0.0		0.0		0.0		173.0 100.0	25.37	0.0		0.0		0.0		0.0		0.0		681.8 5.60
Cerros Las Viudas & Constancia % soil	54.7 1.20	19.54	0.0		0.0		0.0		0.0		0.0		0.0		0.0		161.0 15.59	57.56	0.0		0.0		0.0		64.0 72.89	22.89	279.6 2.30
Pampas Chicama & Chiquitoy Viejo % soil	1520.8 33.37	52.36	493.8 53.19	17.00	431.3 14.53	14.85	24.3 1.51	0.83	0.0		0.0		0.0		0.0		91.8 8.89	3.16	268.8 100.0	9.25	0.0		73.7 100.0	2.54	0.0		2904.6 23.85
Lescano & Quebrado de Oso % soil	0.0		0.0		0.0		0.0		50.0[4] 24.67	16.67	0.0		250.0[5] 100.0	83.33	0.0		0.0		0.0		0.0		0.0		0.0		300.0 2.46
Pampas Esperanza, El Milagro, Huanchaco % soil	0.0		0.0		0.0		1585.0 98.49	79.85	0.0		0.0		0.0		0.0		400.0 38.75	20.15	0.0		0.0		0.0		0.0		1985.0 16.30
Total	4557.1	37.42	928.4	7.62	2967.6	24.37	1609.3	13.21	202.7	1.66	27.1	0.22	250	2.05	173.0	1.42	1032.3	8.48	268.8	2.21	0.0		73.7	0.60	87.8	0.72	12177.5
Excavated fields-coastal[3] % soil	310.9 19.85	25.41	0.0		25.0 64.60	2.04	196.0 100.0	16.02	0.0		0.0		0.0		0.0		0.0		0.0		26.82 100.0	2.14	665.2 26.09	54.38	0.0		1223.15 27.95
Salamanca fields % soil	1255.6 80.15	39.82	0.0		13.7 35.4	0.43	0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		1884.2 73.91	59.75	0.0		3153.5 72.05
Total	1566.5	35.79	0.0		38.7	0.88	196.0	4.48	0.0		0.0		0.0		0.0		0.0		0.0		26.20	0.60	2549.4	58.25	0.0		4376.65

1 For an explanation of the soils symbols, see Map 3.

2 Areas of soils measured from Map 4 with electronic planimeter.

3 Does not include 5 areas of excavated fields in the Moche Valley.

4 Area of Quebrada de Oso fields, as determined by Kus (1972:155).

5 Area of Lescano fields, as determined by Kus (1972:186).

prehistorically exploited region of Mocán consists of flat unirrigated eutric fluvisols which are classified as marginal for intensive agriculture (Fe(un)-a 4) (see Table 13 and Map 4). These soils cover some 41.24 percent of Mocan or approximately 2,414.1 hectares. The remaining 2.61 percent, or 152.7 hectares of eutric fluvisols in the Pampa de Mocán are classified as flat, but as only marginal to useless for agricultural purposes (Fe(un)-a 4-8) (see Table 13 and Map 4).

Analyses of a eutric fluvisol from the Pampa de Mocán indicate that the C1 and C2 horizons (0-20 cm and 20-60 cm, respectively) contain 80 and 86 percent sand, respectively. Such high concentrations of sand in conjunction with a clay content of only 1 percent in each horizon is not conducive to the retention of irrigation water. The result is a droughty soil which must be watered frequently and/or planted in drought resistant crops. Regrettably, samples from soil horizons below 60 cm were not collected. The nature of the material underlying this horizon could significantly affect the suitability of these soils for the cultivation of deeply rooted crops.

Eutric regosols comprise the remaining 6.48 percent (379.5 hectares) of the soils in the Pampa de Mocán. These soils have been classified as flat, but useless for agricultural purposes.

In general, the soils in Mocán can be described as poorly developed sandy soils with a low organic matter content (0.40 percent) and poor water retention qualities. An analysis of soil from the

Pampa de Mocán indicates that the eutric fluvisols in this region are deficient in available phosphorus (ONERN 1973, 2:83). This is a common occurrence in soils which develop in arid regions. Such a deficiency could be overcome by the addition of guano to the cultivated fields.

Of the 5,853.4 hectares which were exploited during the prehistoric period, fully 90.91 percent (5,321.48 hectares) are classified as arable by modern standards. These standards are, of course, based on modern crops and cropping patterns and are probably not entirely applicable to the prehistoric crops and patterns.

In the following section, I will briefly present a hypothetical reconstruction of the development and functioning of the prehistoric canal and field system in the Pampa de Mocán. As I have previously noted, the distribution of canals suggests that the exploitation of this region proceeded in a series of stages with each stage incorporating more land at a higher elevation, proceeding from the lowest canal to the highest canal (see Map 3). This was apparently accomplished through the sequential rebuilding of the maximum elevation canal (m.e.c.) in order to divert water to fields at higher elevations. Given the extent of fields in Mocán, only during the initial stages of exploitation could this area have been irrigated by a single canal. As more land was brought into production by raising the maximum elevation canal, adjustments would also have had to have been made in the canals immediately below the m.e.c. in

order to provide adequate water to the fields it formerly irrigated.

An investigation of the area to the east of Hacienda Facala could provide much information regarding this sequence of development. At this point the canals irrigating Mocán are closest together, and it is here that sequences of construction and superposition might most easily be deciphered.

Unfortunately, given the lack of fieldwork, it is not possible to carry out a hydraulic analysis in which the cultivated area is seen as a function of the parameters of the canals from which it is irrigated (Farrington and Park 1978; Ortloff et al. n.d.). Due to the scale of the available aerial photos (1:15,000), photogrammetric measurements are not of sufficient accuracy to allow the estimation of canal discharges. Rough measurements, however, do confirm the expected in that adjustments in the size of the major canals apparently were made to accommodate the reduced flow after the turnouts of large laterals.

Of all the crops grown during the late prehistoric period on the the North Coast, maize and cotton are the most likely to have been cultivated in the Mocán fields. The indigenous races of maize and the native cottons are well adapted to marginal soils such as those in the Pampa de Mocán.

Gorbman, et al. (1961) have described twelve races of maize which have either been recovered from Early Intermediate (Mochica), Late Intermediate (Chimu), or Late Horizon (Chimu/Inca) sites, or are represented on ceramic vessels from these periods (see Table 14).

Table 14. Races of Maize found on the North Coast from the Early Intermediate to the Late Horizon and their modern descendants.[1]

Prehistoric Race	Cultural Period	Modern Descendant Race	Modern Elevation Range	Modern Growing Period	Comments
Proto-Pardo	Colonial? Chimu?	Pardo	Low central coast valleys	99 days at low elevations	A single ear of this race was recovered from Chan Chan. This race may be a post-conquest introduction and does not grow well outside of the region of low winter clouds. Most likely not grown on the North Coast. The ear recovered from Chan Chan was ambiguous and may actually be a Cuzco variant.
Proto Confite Morocho	Chimu/ Inca	Confite Morocho	2500-3000 m	116 days at high elevation 112 days at med. elevation	This popcorn is exhibited on a single Chimu/Inca vessel. There is no archaeological evidence for its cultivation on the North Coast.
Proto-Cuzco	Chimu	Cuzco	2400-3300 m	148 days at 3200 m 129 days at 2800 m	The wide distribution of this large highland variety may be the result of Inca agricultural policies. A single Chimu vessel exhibits one ear which may be of the Cuzco race.
Proto-Chancayano	Mochica/ Chimu?	Chancayano	Low central coast valleys	96 days at 250 m	This race appears to be a hybrid of Alazan and Pardo. It is represented on only a single Moche vessel.
Proto-Rabo de Zorro	Chimu & Mochica	Rabo de Zorro	2300-3200 m	142 days at 3200 m 129 days at 2800 m	This appears to be a north highland maize.
Proto-Ancashino	Chimu & Mochica	Ancashino	2700-3100 m	143 days at high elevation	This is a highland maize probably introduced to the coast by trade.
Proto-Kculli	Chimu & Mochica	Kculli	2300-3000+ m	137 days at high elevation	This is a highland maize used for dyeing foods and beverages.
Proto-Alazan	Chimu & Mochica	Alazan	Low North Coast valleys	approximately 79 days on North Coast	This is the preferred maize for the production of chicha. It is frequently grown in marginal areas with a poor water supply as it is highly drought resistant. Two ears of this race have been recovered from Chimu context at Chan Chan.

Table 14.(continued)

Prehistoric Race	Cultural Period	Modern Descendant Race	Modern Elevation Range	Modern Growing Period	Comments
Proto-Pagaladroga	Mochica	Pagaladroga	Low North Coast valleys	103 days	There is widespread archaeological evidence of this race during the Early Intermediate on the North and Central Coasts. This race is one of the parents of the Alazan race.
Proto-Mochero	Mochica	Mochero	Low North Coast valleys - less than 50 m	65-70 days on North Coast	This is a very drought resistant race which was ancestor (with Pagaladroga) to the Alazan race. Mochero is a very rapidly maturing race which can be harvested only 3½ months after planting. It is second only to its offspring Alazan as the preferred maize for chicha.
Proto-Rienda	Mochica	Rienda	Low North Coast valleys	113 days on central coast	Archaeological evidence of this race has been recovered from the Viru Valley, but it is hypothesized that it once extended all the way to the Lambayeque.
Proto-Confite Puntigudo	Mochica	Confite Puntigudo	2500-3500 m	136.7 days at high elevation 78 days at sea level	A single Mochica vessel exhibits this highland race of primitive fasciated popcorn.

1 - adapted from (Grobman, et al. 1961)

Six of these races are lowland varieties which can be successfully grown on the coast. The remaining six are highland varieties and probably represent trade items. Of the lowland races, Proto-Alazan seems to be the most likely to have been grown on the North Coast after the Early Intermediate. If Proto-Alazan, like the modern race Alazan, was raised for use in the production of chicha, it seems probable that other races, possibly Proto-Rienda and/or Proto-Pagaladroga, may have been raised for food purposes.

The modern Alazan race of maize is often planted in marginal areas of the North Coast Valleys which lack adequate water supplies for other economic crops (Gorbman, et al. 1961). A high resistance to drought and a short growing season make it possible to raise maize in an area that would otherwise be abandoned. If Proto-Alazan exhibited the same characteristics, it would have been well suited to cultivation in the Pampa de Mocán.

The native cottons of Peru (Gossypium barbadense) offer a number of distinct advantages for their cultivation in marginal soils. Recent investigations (Vreeland 1978) indicate that the native Peruvian cottons are highly resistant to the indigenous pests and diseases which attack the modern hybrids. In addition, the native cottons are perennials, unlike the modern hybrids, and as a result do not need to be replanted every year. The productive life span of the Peruvian cottons is about six years, beginning one year after planting (Vreeland 1978).

Lint is produced throughout the year on the wild plants studied by Vreeland (1978). Year around lint production might help to explain the lack of a large population center in this area. Since lint production was not concentrated into a single harvest period, a small resident population could probably have harvested most, if not all, of the crop without the need for additional labor. Only during planting and possibly after the fourth year of production when the plants are pruned (Vreeland 1978) would a larger labor force be required.

Perhaps the most important characteristic which adapts the indigenous cottons to marginal lands is their ability to tolerate highly salinated soils (Masson 1974) and to survive long periods without large or regular irrigations:

> In these arid soils the local farmers assert that this cotton can survive up to five years without irrigation, due to its fine and extensive root system (translation of Vreeland 1978:21).
>
> En estos suelos aridos los propios campesinos aseveran que este algodon puede sobrevivir hasta cinco anos sin recibir las aguas de irrigacion, debido a su fino y extenso sistema de raices (Vreeland 1978:21).

These characteristics would seem to ideally adapt the native cottons to cultivation in the Pampa de Mocán. The indigenous Peruvian cottons have one other unique characteristic which might provide additional circumstantial support for their cultivation in this area. The cottons which are native to the Peruvian coast come in a variety of different colors ranging from white to a dark purplish

brown. In order to obtain a uniform colored fiber, the cotton lint must be exposed to the sun. This process permanently fixes the color of the cotton fibers. For large scale production such as from the fields in the Pampa de Mocán, large areas protected from the wind would be necessary to accomplish this operation. The large rectangular enclosures (Category 2) which I described earlier could well have served this function.

Vreeland (1978) estimates that under ideal conditions, with a plant density of approximately 1100 plants per hectare, each plant would produce approximately one kilogram of raw cotton per year, or about 1,000 kilograms of cotton per hectare. One thousand kilograms of raw cotton yields about 400 kilograms of cleaned cotton. This compares favorably with the intensively cultivated hybrids. Under intensive irrigated and fertilized cultivation in the Cañete Valley, the modern hybrid produced an average of 643 kilograms/ hectare of cleaned cotton, while between 1955 and 1957 irrigated hybrid cottons in the Lambayeque Valley produced only 285 kilograms/ hectare of cleaned cotton. Using Vreeland's estimates, if all of the Pampa de Mocán were planted to cotton the annual yield would be 2,341,200 kilograms, or 2,341.2 metric tons (2,580.7 tons) of cleaned cotton. It is, of course, highly unlikely that the entire area was planted to only a single crop. As I noted earlier, not all of the area potentially served by the Ascope and associated canals appears to have been cultivated.

Not only is the Pampa de Mocán located on potentially

droughty, marginal soils, but its elevation and long distance from the river might suggest that the available water supply was not as secure as that of older, lower canals. It seems likely that the Mocan fields were constructed in order to utilize the "excess" water available during the period of maximum river discharge from mid-January to the end of April. The ability to survive extended periods of drought would therefore be a very important characteristic for crops grown in Mocán.

Both the Alazan race of maize and the native cottons are drought resistant and would have been well suited to cultivation under these conditions. The cultivation of a perennial crop like the Peruvian cottons in the Pampa de Mocán offers several advantages over the cultivation of an annual such as maize. In addition to the obvious advantage of not having to replant the crop every season, the drought resistant cottons would likely survive and perhaps even produce a small harvest during very dry years when insufficient water was available to bring maize to maturity. In all likelihood, the Pampa de Mocán was not planted to only a single crop, but rather to two or more drought resistant crops of which Alazan maize and the native cottons are the most probable.

Not only are these crops well adapted to cultivation on marginal lands such as the Pampa de Mocán, but they also represent commodities of particular importance to the Chimu State. Chicha played an important part in the religious and ceremonial activities of many Andean peoples including the coastal Yungas. The demand for

cotton and cotton textiles during the late prehistoric period must have been truly prodigious. Schaedel (1977) has estimated that the Chicama and Moche Valleys alone could have had a population of almost 65,000 people during the late prehistoric period. In addition to the cotton required for clothing and utilitarian items such as fish nets, cotton and textiles played a significant role in the ceremonial and religious activities of the Peruvian prehistoric peoples.

In summary, a series of seven prehistoric canals irrigated an area potentially as large as 5,850 hectares in the Pampa de Mocán. The extensive fields still found in this area are located above the limit of modern cultivation and appear to be the result of a state project carried out in several stages on virgin, but marginal lands. Environmental, archeological, ethnohistorical, and botanical evidence indicates that the most likely plants to have been cultivated in the Pampa de Mocán are maize, of the Alazan race, and the native colored cottons.

The Pampa de Mocan seems to represent something of a special case, at least with regard to the prehistoric canals and fields preserved in the lower Chicama Valley. The Mocán canals and fields appear, in the highest canals and fields, at least, to represent a more or less complete irrigation system. The Ascope Canal was apparently constructed primarily to irrigate the Mocán fields. With the sole exception of the Intervalley Canal and the field systems

at Lescano and Quebrado de Oso, all of the other prehispanic canals and fields preserved in the lower Chicama Valley represent only fragments of larger systems. The fact that land in the Pampa de Mocán is of only marginal value for modern agriculture has undoubtedly contributed to the preservation of this system.

Approximately 681 hectares in the Pampa de Paijan and a small area on the south side of Cerro Azul exhibit canals and fields above the present limits of cultivation. The smaller area of fields (172 hectares) may be associated with Site #60 which extends both above and below the major canal which irrigated this region. It is not possible to assign a date to these fields, as neither the fields nor the site have been investigated in the field. The architectural remains, however, have the general appearance of Early Intermediate (Mochica) period huacas. The soils found in this area are flat eutric regosols (97.9 hectares) and eutric fluvisols (74.1 hectares) (See Table 13). As in the case in the Pampa de Mocán, the soils described as irrigated (Fe(i)-a 1-3) are presently uncultivated, but appear to have been irrigated in the recent past.

The larger area of canals and fields in the Pampa de Paijan is also uninvestigated and of uncertain age. The fields in this area are reminiscent of those in the Pampa de Mocán, suggesting that they were constructed in a large unit on virgin lands. This area encompasses about 510 hectares, of which 85 percent (435 hectares) is flat unirrigated eutric fluvisols (Fe(un)-a 3), while the remaining 15 percent (75 hectares) is flat eutric regosols (Re-a 4)

(see Table 13). Analyses of eutric fluvisols from the Pampa de Paijan (ONERN 1973, 2:83) indicate that these soils have a lower sand content (66-72 percent) and a higher silt (18-24 percent) and clay (10 percent) content than those in the Pampa de Mocán. As a result, these soils have a somewhat better water retention capacity. The organic matter (.48-1.64 percent) and available phosphorus (85-261 kilograms/hectare) are also considerably higher. In general, these soils are more fertile and have a higher water retention capability than those in Mocan.

An even smaller area of canals and fields than those bordering Cerro Azul is found along the southern and southwestern sides of cerros Las Viudas and Constancia. A single canal encompasses an area of about 280 hectares which contains three soils: eutric fluvisols (Fe(i) 1-30, 55 hectares) (again uncultivated), eutric regosols (Re-a 8, 151 hectares), and desertic lithosols (Ld-c 8/7, 64 hectares) (see Table 13). Unfortunately, neither archaeological nor soils research has been conducted in this area. It is not possible, therefore, to provide data regarding the age of the agricultural features or on the agricultural potential of the soils of this area. It is unlikely, however, that the lithosols included in this area were ever cultivated. The remaining 216 hectares probably represents only a small and relatively minor part of a much larger irrigation system.

A complex network of individual and interconnected canals and fields covers an area of approximately 2,900 hectares in the Pampa

Chiquitoy Viejo and Pampa Chicama. The location and topography of these pampas makes them the logical choice for the expansion of agricultural production on the south bank of the Chicama River. In order to incorporate this land, it is only necessary to extend pre-existing canals. While this would probably require the reconstruction of the old canal channel, it would require far less labor than surveying and building an entirely new canal, as was necessary in the Pampa de Mocán.

The major canals found in this area are illustrated on Maps 3 and 4 and have been assigned letters to facilitate their identification and discussion. Canal a is the highest major canal in this area. This canal branches off of canal b in the vicinity of the site Chicamita (#73) and parallels its course for a distance of about 5.6 kilometers. The southern end of this canal appears to reconnect to canal b. Canal a may represent an attempt to carry water along a higher contour which was abandoned as unfeasible.

Canal b seems to have served as the highest functional major canal irrigating this area. This canal ultimately extends around the northern point of Cerro Piedra Parada and continues to the south beyond the area covered by the 1943 aerial photos. Several laterals connect this canal to canal d (see Maps 3 and 4) which indicates that they probably functioned at the same time. These two canals (b and d) probably irrigated most of the northern half of this area (Pampa Chicama) and perhaps a significant portion of the southern half (Pampa Chiquitoy Viejo), as well.

Canal c appears to be modern or, at the very least, younger than canals b and d. This canal is superimposed over laterals and fields which connect canals b and d and, as such, must postdate them. Much of the area below Canal c contains what appear to be modern parallel furrows or borders running perpendicular to the long axis of the larger field borders. The clarity with which these furrows appear on the aerial photographs, as well as their extreme uniformity, suggests that they are the result of an unsuccessful attempt to re-cultivate this area using modern mechanized agricultural methods. Also, the presence of a large area of second growth trees and shrubs below Canal c indicates that this canal is receiving water from modern canals for at least part of the year.

Canal e is badly disturbed and difficult to define. In several places this canal is overlain by later fields originating at canal d. Canal e may represent an earlier attempt to exploit this region which was abandoned when the higher canals (b and d) were completed. Canal f is a short section of canal which appears to be an extension of a lower canal now rehabilitated or destroyed by modern cultivation.

Canals g and h, as well as several additional short canals form part of a field system composed of a major canal (g) and several laterals which supplied water to an area east of the site of Chiquitoy Viejo (Site #75). Canals i, j, and several associated canals also form part of a field system east and south of Chiquitoy Viejo. A prehistoric road believed to date to the Inca Period (Conrad 1977)

appears on the 1943 aerial photos to have been cut by canal i. Conrad (1977:fig. 3), however, shows the road overlaying the canal. This is an important point as it provides a means of dating at least the most recent use of the canal. Serpentine furrows within the site of Chiquitoy Viejo have been assigned to the Colonial Period (Conrad 1977). In all probability, these furrows were irrigated from canal i. If this is the case, then at least the most recent use of this canal occurred during the colonial period. Within the past few years, part of this system has been rehabilitated in order to recultivate the land surrounding Chiquitoy Viejo (Rodriguez Suy Suy personal communication). Additional fieldwork will be necessary, however, before it will be possible to positively state the age and period(s) of use of this canal and the associated fields.

The Pampa Chicama and Pampa Chiquitoy Viejo contain a considerable number of architectural remains. These remains exhibit a very broad range of variability from small rectangular structures measuring about 6 x 6 m to the large rectangular compound of Chiquitoy Viejo (300 x 250 m). and the pyramid and annex of Huaca Colorado (Site #76). Two large enclosures reminiscent of Category 2 structures in the Pampa de Mocán occur in the Pampa Chicama area. Three mounds and associated structures are also found in the Pampa Chicama. On the basis of their relationship to the better preserved canals and fields, it appears that these structures may represent earlier efforts at the agricultural

exploitation of this area. This is entirely conjectural, of course, and remains to be tested in the field.

A particularly interesting structure is located on a small cerro to the east of the site of Chiquitoy Viejo. This enclosure contains several large rooms as well as two parallel rows of small uniform "storage" rooms. Fourteen or fifteen rooms can be counted from the aerial photos. The topographic setting of this site as an isolated structure near large expanses of prehistoric field systems and within close proximity to major canals is strongly reminiscent of the rural administrative centers described by Keatinge (1974) and Keatinge and Day (1973). While the internal plan of this structure appears to differ significantly from those described by Keatinge (1974), the geographic similarities are striking. Regrettably, questions regarding the exact role played by the various structures found throughout this area of fields must await additional fieldwork.

The Pampa Chiquitoy Viejo and Pampa Chicama contain three primary soils which have been grouped into seven use classifications (see Table 13). Eutric fluvisols compose 85 percent (2,470 hectares) of the soils in this area. The remaining 15 percent is composed of eutric regosols (360 hectares) and gleyic solanchaks (73 hectares). Over one half (52.4 percent) of the soils in the prehistorically cultivated region of this area have been classified as irrigated (Fe(i)-a 1-3). This is misleading because, as in the Pampa de Mocán, virtually all of the land so classified appears to be

forested rather than cultivated.

The second largest classification of soils in this area is composed of flat unirrigated eutric fluvisols which are classified as marginal for intensive agriculture (Fe(un)-a 3) (see Table 13 and Map 4). As I noted earlier, the area surrounding the site of Chiquitoy Viejo (Site #75) has recently been brought back into production. A large portion of this rehabilitated region is composed os soils having this classification. These soils cover 17.0 percent or 493.8 hectares in the Pampa Chiquitoy Viejo. Eutric fluvisols with a use classification of 4, useful for pasturage and forests, but generally not considered as arable, are found on 431.3 hectares (14.8 percent). Less than 1 percent (24.3 hectares) of this area includes flat unirrigated eutric fluvisols which have been classified as totally useless for agricultural purposes (Fe(un)-a 8).

Eutric regosols comprize only 12.4 percent, 360.6 hectares, of the soils found in this area. Most of the regosols found in this region (268.8 hectares) are flat eutric regosols which are marginal or useless for agricultural purposes (Re-a 4 and 8). Approximately 92 hectares in the cultivated portion of the Pampa Chiquitoy Viejo are composed of flat eutric regosols classified as useless for agriculture (Re-a 8). Gleyic solanchaks comprise the remaining 2.5 percent (73.6 hectares) of this area. These 73.6 hectares have been classified as marginal to useless for agricultural purposes.

In general, the soils in the Pampa Chicama and Pampa Chiquitoy Viejo contain a higher silt content and, hence, a higher water retention capacity that those in the Pampa de Mocan. It is possible that the higher percentages of silt and clay found in these soils is the result of the application of silt-laden irrigation water during the prehistoric period. It may, in fact, be possible under controlled conditions to use the relative percentages of the silt and clay fractions of irrigated soils to determine the relative period of time a given area was cultivated. The soils in this area are also low in organic matter and might have required the addition of guano to supply the necessary phosphates.

Two additional areas of agricultural fields and canals, both associated with the Intervalley Canal, are located in the lower Chicama Valley. The largest encompasses an area of 500 hectares, of which about half was cultivated (Kus 1972:186). This area is located between Cerro Gasñape and Cerro Tres Cruces on the Plain of Lescano. The fields in this area are entirely confined to an area of heavily dissected eutric fluvisols (Fe(un)-c 8) which have been classified as useless for agricultural purposes (see Table 13 and Map 4). No soils analyses have been conducted in this area, but the soils are probably similar to those found in the Pampa de Mocan and the Pampa Chicama.

The second area of fields associated with the Intervalley Canal is located in the Quebrada de Oso. Kus (1972) has mapped and described in detail the agricultural features found in this

area, and Keatinge (1974) and Keatinge and Day (1973) have discussed the architectural remains, so there is no reason to repeat them here. This is a relatively small area of fields of only slightly more than 50 hectares. These fields are confined to flat eutric fluvisols (Fe(un)-a 4 and 8) which are classified as of only little or no use for agricultural purposes. Analyses of these soils in the adjacent Pampa Pascona indicate that they are sandy loams and probably have fair to moderate water retention capabilities.

These two areas of fields, as well as the approximately 1600 hectares in the Moche Valley irrigated by the Intervalley Canal, must of necessity date to the same period as the Intervalley Canal itself. Kus (1972) states that the Intervalley Canal was apparently constructed between 900 and 1000 A.D. Recent work by the Programa Riego Antiguo has shown that the Intervalley Canal may have functioned in some capacity for as long as 300 to 400 years (Ortloff, et al. n.d.).

Evidence of prehistoric agricultural exploitation in the lower Chicama Valley is not limited to irrigation canals and fields located above the limits of modern cultivation. Additional evidence occurs as two types of excavated fields found along the coast and in areas of poorly drained soils. In order to distinguish between these two types, I will refer to them simply as Type a and Type b. Type a fields exhibit a wide range of variation of from only a few square meters to several thousand square meters. Type b fields can be recognized by the discontinuous rectilinear embankments which

occur along the borders of the fields. These characteristic embankments appear to represent accumulations of soil systematically removed from the field surface. Ford and Willey (1949:26) noted the presence of artificial accumulations of salinated soil in and around excavated fields in the Viru Valley, and West (n.d.) has described similar embankments, also in the Viru Valley, associated with sangrias or drainage cultivation.

Twenty areas containing both Type a and Type b fields are visible on the 1943 series aerial photos. These areas generally occur immediately behind the shoreline and are frequently associated with small closed drainages where the water table is at or near the surface. The fields in these areas range in size from less than one hectare to more than 250 hectares. Type a and Type b fields have been grouped together in these areas due to the difficulties of distinguishing such small areas on a map of the scale available.

There is a strong correlation between the occurrence of excavated fields, both Types a and b, and the distribution of gleyic solonchak soils in the lower Chicama Valley (see Table 13 and Map 4). Of the approximately 1,223 hectares of fields found in the twenty areas mentioned above, 665 hectares (54.38 percent) are found on solonchak soils (Sg-a 4 and 8). The remaining 45.62 percent is composed of eutric fluvisols, of which 311 hectares have been returned to cultivation (see Table 13). Unfortunately, the lack of fieldwork on these remains precludes the possibility of assigning

dates to the excavated fields in the lower Chicama Valley.

A very extensive area of Type b fields is located predominantly to the northeast of Hacienda Salamanca where they cover an area of approximately 3,153 hectares. Most of this area is cultivated as small individual plots, many of which conform to the prehistoric field borders. Many of the prehispanic embankments have been leveled by the mechanized cultivation of sugar cane, but are still visible on the 1943 aerial photos as crop marks and soil color differences. A particularly intriguing aspect of these fields is that the characteristic embankments may provide evidence for the reconstruction of prehistoric irrigation and/or drainage systems in this area. These embankments often exhibit patterns very similar to canal systems.

Almost 60 percent (1884 hectares) of this area consists of gleyic solonchaks (Sg-a 4 and 8), while the remaining 40 percent (1,269 hectares) is composed of eutric fluvisols (Fe(i)-a 1-3 and Fe(un)-a 4) (see Table 13 and Maps 3 and 4). The presence of accumulated salts in upper horizons is characteristic of solonchak soils. It is not surprising, therefore, to find evidence of a prehistoric technology designed to render these soils productive, especially in light of the fact that solonchak soils cover some 7,800 hectares in the lower Chicama Valley. By artificial drainage and/or removal of salinated surface horizons, these soils could be made productive. An organic mulch may also have been used to reduce evaporation. Additional fieldwork in this area would provide

valuable information on the methods used by the prehistoric inhabitants of the North Coast to exploit regions of humid soils.

A comparison of the distribution of prehispanic fields and modern soils in the lower Chicama Valley reveals some interesting patterns. Of the 12,177 hectares of prehispanic irrigated fields discussed above, 86.55 percent, 10,540 hectares, occur on eutric fluvisols. Such a high percentage seems to suggest a strong preference for fluvisols which is agriculturally sound on the basis of the relative productive capacity of the alternative soils available in the lower valley. Of the eutric fluvisols irrigated by these canals and fields, the most frequently utilized soils are those classified as appropriate for intensive cultivation, classifications 1-3 (52 percent, 5,485 hectares). Twenty-eight percent, 2,968 hectares, of these prehistorically cultivated soils are classified as useful for permanent exploitation such as pasturage or forest (classification 4). In other words, 80 percent, 8,453 hectares, of the prehistorically cultivated fluvisols above the limits limits of modern cultivation are classified as useful for some form of agricultural production.

The presence of prehistoric fields on eutric fluvisols with a use classification of 4 indicates that these soils were not considered as useless for the cultivation of field crops during the prehistoric period. Modern changes in crops and technology have relegated soils once considered suitable for cultivation to less intensive, more permanent exploitation, in the form of pasturage

and forests. As I have suggested above, these areas may have been used for the cultivation of perennial drought resistant native cottons. This crop, as in the case of modern pasture and wooded regions, requires less intensive, more permanent cultivation than annual field crops and would be well adapted to these soils.

The predominance of soils classified as suitable for agricultural exploitation in regions of irrigated prehistoric fields suggests that the environmental factors important to the modern agricultural planner were also significant to his prehistoric counterpart. It also suggests that prehistoric decisions regarding the agricultural development of specific areas in the lower valley were based on a thorough knowledge of soils, topography, and plant requirements. None the less, prehispanic canals and fields are found to occur on eutric regosols, the majority of which have been classified as useless for agricultural purposes. If, as I have suggested above, the prehistoric inhabitants of the North Coast possessed a sophisticated understanding of the environmental factors affecting irrigated agriculture, it is somewhat surprising to find almost 1500 hectares of fields on soils of very little, if any value, for cultivation (see Table 13 and Map 4). This can be explained, of course, as merely the result of misidentification made in the initial evaluation of areas to be cultivated. Or it could be the result of necessity, which I think is more likely. The location of extensive prehistoric fields in areas of soils which are marginal to useless for agricultural purposes seems to suggest that the areas

of better soils were already in production when these fields were surveyed. In other words, it appears that during the prehistoric period, most likely during the Late Intermediate, all of the prime agricultural land was under cultivation, and in order to expand production it was necessary to incorporate the more marginal lands. This expansion into marginal lands, in every case discussed here, incorporated the best possible soils. As can be seen on Map 4, continued expansion would have necessitated the incorporation of soils having even lower agricultural potential. In light of this evidence, it appears that the environmental limits of the lower Chicama Valley had very nearly been reached during the late prehistoric period.

Modern agricultural activities have largely destroyed the evidence of prehispanic land use in the majority of the lower valley. As a result, there is little direct evidence upon which to base a reconstruction of land use patterns in the central portion of the lower valley. The distribution of archaeological sites in this part of the valley could shed important light on this problem, but is beyond the scope of this report. Indirect evidence in the form of prehistoric canal and field distributions and their environmental setting, as discussed above, however, may also provide clues to the resolution of this problem. Virtually all of the land well suited to agricultural exploitation is presently under cultivation. Some 45,950 hectares are now cultivated in the lower Chicama Valley (ONERN 1973 I:170). It is logical to assume, in light of the

evidence indicating a sophisticated knowledge of agriculture and environments, that the prehispanic inhabitants of the North Coast would not extend cultivation into marginal areas until it became necessary. Presumably those areas well suited to cultivation would have been maximally exploited before marginal lands were incorporated. It is not unreasonable, therefore, to assume that with the exception of the areas above the limits of modern cultivation, the area of prehistoric agricultural exploitation roughly corresponded with the area presently under cultivation. With the addition of the prehispanic fields described above, the maximum total extent of prehistoric cultivation incorporated approximately 58,000 hectares in the lower Chicama Valley. An additional area, possibly as large as 1600 hectares, was irrigated by the Intervalley Canal in the Moche Valley, bringing the maximum total area irrigated by the Chicama River to about 59,600 hectares. Whether or not this entire area was under cultivation at the same time cannot be determined from the available evidence. However, the similarities of canal and field layouts and architectural remains between the three largest areas of fields, Pampa de Mocán, Pampas Chicama and Chiquitoy Viejo, and the Pampas Esperanza and Huanchaco in the Moche Valley, suggest that they may well have been contemporary.

Kus (1967) has argued that the presence of large and extensive stands of trees made a large portion of the lower valley bordering the river unsuitable for cultivation. He states that problems of poor drainage would have made the introduction of irrigation

useless and that only after the introduction of modern machinery could these areas have been cleared and cultivated. Large-scale clearing of wooded areas, however, does appear to have taken place during the prehistoric period. West (n.d.) has described an area of prehispanic fields in the Viru Valley in a swampy region which was undergoing modern rehabilitation. This area was almost certainly forested prior to its prehispanic cultivation. The extensive area of type b excavated fields near Hacienda Salamanca was also very likely forested prior to its cultivation during the prehistoric period. As I have discussed in this and previous chapters, prehispanic agriculture was not limited to canal irrigation. It also included techniques of drainage cultivation used to exploit poorly drained soils such as those described by Kus (1967). It is not appropriate, therefore, to eliminate areas of potential prehistoric cultivation solely on the basis of poorly drained soils and/or the presence of extensive areas of trees. Farrington (1974) has suggested that methods of cultivating poorly drained heavy soils were not found on the coast until the Late Horizon. West's investigations (n.d.) in the Viru Valley suggest, however, that they occur earlier, possible as early as the Gallinazo (Early Intermediate Period).

The lack of sufficient water for irrigation is often cited as the factor which most limits agriculture in the lower Chicama Valley. A comparison of the irrigation requirements per hectare to the mean monthly river discharge provides an estimate of the amount

of land which could be irrigated in an average year (see Table 15). A similar comparison of water requirements to the monthly river discharges for very wet (1933) and very dry (1950) years can provide a range of potentially irrigable land (see Tables 16 and 17). As I have noted in previous chapters, the late prehistoric inhabitants of the North Coast cultivated a wide variety of plants in several diverse environments. These factors would, of course, affect the irrigation requirements for any given area. For the purposes of this discussion, however, I have chosen to use the irrigation requirement estimates for maize as a representative cultigen. The importance of maize to the prehistoric North Coast inhabitants would seem to justify such a choice.

An ONERN (1973:242-248) study has estimated that maize requires from 11,157 to 8,575 cubic meters of water per hectare to reach maturity in the lower Chicama Valley. These estimates seem unduly high when compared to others available for this area (Farrington and Park 1978:263; Rodriguez Suy Suy 1971:4). However, a comparison of these figures to those determined to have been used in the calculation of future water requirements, as calculated from Cuadros 19-26 (ONERN 1973, 2:105-112), indicates that the larger estimates were not used. Considerably smaller estimates, ranging from 5920 to 7105 cubic meters per hectare, were actually used to determine future water requirements. The larger of these figures compares favorably to an estimate quoted by Farrington and Park (1978: 263) and is in close agreement with the figure of 7500 cubic meters

per hectare as presented by Rodriguez Suy Suy (1971:4). For the purposes of this analysis, a compromise figure of 7200 cubic meters per hectare is probably a reasonable estimate.

Not all of the water removed from the river reaches the fields. Losses due to seepage, evapotranspiration, and evaporation can be considerable. Farrington and Park (1978:263) quoted an estimate that modern unlined canals in the Moche Valley are about 70 percent efficient, while ONERN (1973) has estimated that the canals in the Chicama Valley are approximately 85 percent efficient. The figure quoted by Farrington and Park may well be too low in light of recent work by the Programa Riego Antiguo (Ortloff, et al., n.d.). Investigations along the Intervalley Canal and in the Pampas Huanchaco and Esperanza indicate that substantial amounts of silt were allowed to build up in canals to form a lining or bed into which a subsequent, more efficient canal was constructed. The presence of such a deposit would substantially reduce water losses due to seepage. The 85 percent efficiency presented in the ONERN (1973) study, however, is probably too high. An estimate of 75 percent efficiency, including losses incurred in the application of the water in the fields would seem to be a reasonable compromise.

In order to maximize agricultural production, four growing seasons of four months each are required. By planting crops in January, February, June, and October, to be harvested in May, June, October, and January, the maximum possible land can be irrigated given the nature of the Chicama River discharge. An analysis of the

mean monthly discharge on the basis of the irrigation requirements presented above indicates that approximately 60,307 hectares could be irrigated with the water available in an average year (see Table 15). A similar analysis of the monthly discharges of very wet (1933) and very dry (1950) years, provides a range of from 122,658 hectares to 17,716 hectares, respectively (see Tables 16 and 17).

The area of cultivation determined from the soils and archaeological data (59,600 hectares) is very close to that predicted on the basis of irrigation requirements and the available average annual river discharge (60,307 hectares). The similarity of these two figures seems also to support the hypothesis that by the late prehistoric period efforts were made to maximize the agricultural exploitation of the lower valley. This seems to have been the case not only in regard to agricultural lands, but also in regard to available irrigation water, as represented by the average annual Chicama River discharge.

These predictions are based on several assumptions regarding cultigens, water requirements, cropping patterns, and irrigation efficiencies which I outlined above. Such assumptions are always suspect, but frequently provide valuable insight and suggestions for continued research by illustrating deficiencies in archaeological data collection and analysis. The above assumptions result from an attempt to incorporate modern methods of hydraulic analysis and irrigation water requirements into an analysis of prehistoric agricultural technology and land use. The validity and

Table 15. Maximum area potentially irrigated by the mean monthly Chicama River discharge [1].

Month	Discharge [2] (1,000,000 m^3)	Maximum Monthly Irrigable Area (hectares)	Maximum Irrigable Area per Four-Month Growing Season (hectares)
Jan.	59.27	24,695	
Feb.	121.54	50,641	
March	271.88	113,283	24,695
April	196.19	81,746	25,946
May	72.32	30,133	
June	28.02	11,675	
July	18.13	7,554	4,233
Aug.	12.78	5,323	
Sept.	10.16	4,233	
Oct.	13.04	5,433	
Nov.	13.84	5,767	5,433
Dec.	21.27	8,862	
Jan.	59.27	24,695	

1 Area calculated on the basis of an irrigation requirement of 9,600 cubic meters per hectare per four month growing season.

2 Discharge calculated from Cuadro No. 2, Discargas Medias Mensuales Del Rio Chicama (ONERN 1973 2:88)

Table 16. Maximum area potentially irrigated during a very wet year (1933) [1].

Month	Discharge [2] (1,000,000 m^3)	Maximum Monthly Irrigable Area (hectares)	Maximum Irrigable Area per Four Month Growing Season (hectares)
Jan.	187.59	78,162	
Feb.	380.05	158,354	
March	1258.40	524,333	78,162
April	427.80	178,250	32,521
May	78.05	32,521	
June	44.74	18,641	
July	27.69	11,537	
Aug.	21.35	8,896	7,671
Sept.	17.21	7,171	
Oct.	17.14	7,142	
Nov.	11.53	4,804	
Dec.	11.60	4,833	4,804
Jan.	39.51	16,462	

1 Area calculated on the basis of an irrigation requirement of 9,600 cubic meters per hectare per four month growing season.

2 Discharge calculated from Cuadro No. 2, Discargas Medias Mensuales Del Rio Chicama (ONERN 1973 2:88).

Table 17. Maximum area potentially irrigated during a very dry year (1950) [1].

Month	Discharge [2] ($1{,}000{,}000\ m^3$)	Maximum Monthly Irrigable Area (hectares)	Maximum Irrigable Area per Four Month Growing Season (hectares)
Jan.	6.00	2,500	
Feb.	35.18	14,658	
March	55.98	23,323	2,500
April	79.57	33,154	12,158
May	33.05	13,771	
June	13.92	5,800	
July	9.69	4,037	
Aug.	6.32	2,633	1,575
Sept.	3.78	1,575	
Oct.	3.56	1,483	
Nov.	5.99	2,496	
Dec.	10.98	4,575	1,483
Jan.	23.06	9,608	

1 Area calculated on the basis of an irrigation requirement of 9,600 cubic meters per hectare per four month growing season.

2 Discharge calculated from Cuadro No. 2, Discargas Medias Mensuales Del Rio Chicama (ONERN 1973 2:88).

final utility of these assumptions and this approach must await further investigations.

Throughout this study, I have concentrated on the physical parameters of prehistoric agriculture. This perspective alone, however, cannot provide a full understanding of the significance and role played by agriculture in the prehistoric societies and cultures of the Peruvian North Coast. Studies incorporating history, ethnohistory, ethnography, linguistics, and physical anthropology, as well as archaeology and the physical and agricultural sciences, will be needed if we are ever to even approach such an understanding. This report is merely a summary and extrapolation of some of the evidence presently available on prehistoric Peruvian agriculture on the North Coast and serves primarily to illustrate the general lack of field data necessary to comprehend the significance of agriculture in the development of the prehistoric Peruvian coastal civilizations.

SUMMARY AND CONCLUSIONS

In this report I have attempted to present a summary of our present knowledge and understanding of prehistoric North Coastal agriculture from the perspective of the Chicama Valley. New and unpublished data has been included wherever possible, and a number of hypotheses and lines of research have been suggested. In this final section, I will briefly review the hypotheses presented in the introductory chapter along with a summary of the supporting evidence and suggested lines of research.

A thorough understanding of the basic hydraulic principles of open channel flow and a sophisticated surveying technology of sufficient accuracy to determine a contour of constant slope are demonstrated in the construction of the large prehispanic Peruvian irrigation systems.

On the basis of the available evidence, there can be little doubt that the prehistoric inhabitants of the Peruvian North Coast developed a sophisticated knowledge of hydraulic principles. Variations in canal slope, form, and roughness were manipulated to control flow characteristics, and recent work by the Programa Riego Antiguo indicates that chokes, hydraulic jumps and overflows were used to maximize channel flow characteristics. The presence of stone lined and plastered channels indicates that the problems of channel erosion and seepage losses were recognized by the prehistoric agriculturalists of the North Coast and that methods were developed to reduce their effects.

The construction of very long (in excess of 40 kilometers)

canals over very rough terrain illustrates that some means of maintaining a relatively constant slope over such long distances was developed. The fact that the system was not foolproof can be seen in the numerous unconnected sections of canals found along the Intervalley Canal and paralleling most major canals in the Chicama and Moche Valleys. However, the prehistoric surveying technology appears to have been of sufficient sophistication to allow resurveying to check slopes prior to the completion of the entire canal. The presenceoof uncompleted canal sections below the Intervalley Canal and in the Pampa Huanchaco indicates that such checking was carried out and canal sections of the incorrect slope abandoned (Ortloff, et al. n.d.). The presence of disconnected canal sections also indicates that the prehistoric canals were constructed in a series of unconnected segments.

Continued research on the physical characteristics of the prehistoric North Coast canals can shed much light on one of the most sophisticated prehistoric agricultural technologies ever developed.

In spite of the highly developed hydraulic and construction technology of the late prehistoric period, the available methods were not adequate to construct impoundment reservoirs for the storage and redistribution of irrigation water.

The construction of earthen aqueducts across the outlets of quebradas has led some scholars to postulate that these structures also functioned as damns for the impoundment of irrigation water during periods of high river discharge for release during

periods of low discharge. The analysis of one such structure, the famous Ascope Aqueduct, indicates that it could not have served this function. The distribution of prehistoric remains within the presumed impoundment basin and the lack of structures intended for the removal of the impounded water, spillways or conduits, indicates that this structure was intended to function solely as an aqueduct. A small part of this area may have functioned secondarily as a small reservoir to provide a domestic water source for the local population, however.

Continued investigation of impoundment-like structures is definitely warranted on the North Coast. It seems unlikely, however, that evidence of storage and redistributive structures will be found. The technological problems encountered in removing water from a storage facility while lacking a pump technology does not appear to have been solved by the prehistoric coastal inhabitants.

The primary food plants of the Late Intermediate Period were dominated by field crops such as maize, beans, yuca (manioc), and squash, with a secondary reliance on fruits.

It has traditionally been assumed that the primary food crops during the Late Intermediate were field crops such as maize, beans, yuca, and squash. Recent archaeological investigations, however, have suggested that two fruits, lucuma and guanabana, played a very major part in the diet of the coastal populations during the late prehistoric period (Pozorski 1976). A review of this recent data indicates that preservational factors, probably

resulting from cultural practices and environmental conditions, may have skewed the surviving plant remains in favor of the hard seeded fruits. A reinterpretation of this data in light of these factors indicates that they are not inconsistent with the remains expected from groups relying primarily on field crops with a secondary reliance on fruits.

Investigations incorporating micro-botanical remains (epidermal fragments, phytoliths, pollen) are suggested as potentially useful means of recovering a broader range of plant materials utilized by the prehistoric Peruvian coastal inhabitants. Both cultural and environmental factors serve to bias the floral (and faunal) remains recovered from archaeological contexts. A more thorough understanding of how these factors function to bias the archaeological record is paramount to an understanding of prehistoric dietary practices.

The extensive fields in the Pampa de Mocán represent a high level agricultural project executed by the Chimu State for the cultivation of cotton and/or drought resistant maize.

The Pampa de Mocán is an extensive area of prehistoric canals and fields located on the far north bank of the Chicama River. While very little fieldwork has been conducted in this area, a series of aerial photographs taken in 1943 provide important information on the structure and distribution of the archaeological remains found there. An analysis of these photographs and the distribution of soil types in the Pampa de Mocán illustrates

that the agricultural expansion into this area was a large-scale project (ultimately incorporating over 5800 hectares) designed to incorporate the best possible soils in the region. There is no conclusive evidence that this area was cultivated in either cotton or maize. However, its location, architectural remains, and soils, and the drought resistant nature of these crops suggest that their cultivation there is not unlikely.

The Pampa de Mocán canals and fields represent probably the largest area of prehistoric agricultural remains on the North Coast not substantially altered or destroyed by modern agricultural activities. A thorough investigation of this area should include detailed mapping of canals, fields, architectural remains, and soils, selected excavations of canals, fields and structures, and chemical and micro-botanical analyses of soils.

The prehistoric inhabitants of the North Coast possessed a sophisticated knowledge of environmental factors and developed agricultural techniques to exploit the varied environments found within the lower coastal valleys.

The distribution of prehistoric agricultural features in the lower Chicama Valley indicates that the effects of topography and soil characteristics such as drainage, fertility, water retention capability, and salinity were understood and incorporated in the planning and development of agricultural projects. The correlation betweens areas of prehispanic cultivation and specific soil types and classifications indicates that characteristics

significant to modern agricultural planners were also important to the prehistoric agriculturalists of the North Coast. In several cases, the prehispanic agriculturalists of the Chicama Valley successfully exploited lands presently considered marginal to useless by modern agricultural planners. This was accomplished by developing specialized techniques of cultivation and by cultivating crops well adapted to the environment being exploited.

Continued research on the distribution of prehistoric remains and their associations with the varied environments of the lower valley will shed much needed light on the problem of prehispanic land use. Such research must include detailed environmental assessments and would likely benefit from ethnohistoric and ethnographic studies as well

During the prehistoric period more land was cultivated in the lower Chicama Valley than is presently exploited by modern agriculture.

Through the development of a diversified agricultural technology the prehistoric inhabitants of the North Coast were able to exploit large areas of land not presently under cultivation. The development of an excavated field technology allowed the exploitation of lands now considered marginal or useless for agricultural purposes. By cultivating a variety of plants adapted to the various environments found in the lower valley, salt tolerant and drought resistant cotton and maize, for example, the prehistoric inhabitants of the Chicama Valley were able to

cultivate some 58,000 hectares, as opposed to the 45,950 hectares now under cultivation.

Similar investigations in other North Coast valleys are desperately needed before modern agricultural and other activities destroy the presently available evidence. Kosok (1965) has suggested that the North Coastal valleys all once supported a larger area of cultivation than is presently exploited. Regrettably, he had not fully compiled or presented his evidence prior to his untimely death. The importance of this type of study is paramount for estimates of carrying capacity and population and must be undertaken in order to provide a basis for such studies.

By the late prehistoric period, agricultural exploitation was beginning to press the environmental limits of the lower Chicama Valley.

The maximum extension of prehistoric agriculture is presumed to have occurred during the Late Intermediate Period. A comparison of agricultural features with soils and environmental data strongly suggests that most of the arable land was exploited by this time. Further expansion would have necessitated the exploitation of lands not well suited to agricultural purposes. In several cases, the highest irrigated fields in the lower valley exhibit evidence of clearing, leveling and other modifications necessary to bring them into production. Only in marginal areas would such activities have been necessary on the scale seen in

these remains.

Two important avenues of research are implicit in this hypothesis. The first is the necessity to firmly date the canals, fields, and architectural remains of interest. Radiometric assay of samples collected from controlled excavations in these structures is obligatory. Only after direct temporal association is conclusively demonstrated can studies of system functioning and extension be undertaken. The second avenue of research is through the field investigation of environments and their associated agricultural features. The detailed mapping of these data would provide a direct means of evaluating this hypothesis and should be undertaken in several valleys as a means of determining the extent of this phenomenon on the North Coast.

The investigation of prehistoric agricultural technologies is of more than academic interest. An understanding of these technologies could potentially provide a means of exploiting lands which are presently abandoned. While the wholesale adoption of the labor intensive prehispanic agricultural technologies would be impractical and probably undesirable, a fusion of modern and prehistoric techniques might prove to be a viable option for the exploitation of marginal lands. Archaeological investigations of the type discussed above might contribute to more than just an understanding of Peruvian prehistory. They may provide a practical link between the prehistoric inhabitants of the Peruvian North

Coast and their descendants.

Much of what I have presented above must be relegated to the realm of conjecture. However, while I have not resolved the numerous issues concerning prehistoric agriculture and land use on the Peruvian North Coast, perhaps I have clarified some issues and suggested means for the successful clarification of others.

During the long process of completing this study, I was often reminded of a quote by Mark Twain on the nature of science which could easily be applied to archaeology as well:

> There is something fascinating about science. One gets such wholesale returns of conjecture out of such a trifling investment of fact.
>
> Mark Twain
> Life on the Mississippi
> 1883

APPENDICES

APPENDIX 1. SIZE OF AREA OF STUDY

Area of study calculated by summing total areas of ecological/use zones 1, 3, 4, and 5 from ONERN (1973 Mapa 1) -

1. 45,950 ha.
3. 50,650 ha.
4. 4,800 ha.
5. 2,750 ha.

Total = 104,150 ha. or 1041.50 sq. kms.

In order to determine the percentage of land in the study area useful for large-scale irrigated agriculture, the total area of ecological/use zones 1 and 4 was summed and divided by the total land area included in ecological/use zones 1, 2, 4, 7, 9, 11, and 13 (ONERN 1973 Mapa 1). For an explanation of the inclusion of ecological/use zone 4 in these calculations, see Watson (1978).

$(50{,}750 \div 78{,}100)100 = 64.98\%$

APPENDIX 2. GLOSSARY OF FAO SOILS TERMINOLOGY

Albic horizon - A soil horizon from which clay and free iron oxides have been removed, or in which the oxides have been segregated to the extent that the color of the horizon is determined by the color of the primary sand and silt particles, rather than by the coatings on these particles.

Calcic horizon - A soil horizon exhibiting an accumulation of calcium carbonate.

Cambic horizon - An altered horizon not exhibiting an accumulation of clays, columnar or prismatic structure, or a sodium saturation greater than 15% within the upper 40 cm of the horizon. This horizon also lacks dark colors and accumulated organic matter and shows no cementation, induration, or brittle consistence when moist.

Eutric - good, eutrophic, fertile; used in the classification of soils.

Gleyic - mucky soil, connotative of an excess of water; used in the classification of soils.

Gypsic horizon - A soil horizon exhibiting a secondary calcium sulfate enrichment that is more than 15 cm. thick and which has at least 5% more gypsum than the underlying C horizon.

Histic horizon - An organic soil horizon formed or forming from accumulations of organic material deposited on the surface that is saturated with water for prolonged periods (unless artificially drained). Contains 20 to 30% or more of organic matter.

Ochric horizon - A thin or very light colored soil horizon, or a soil horizon which is both hard and massive when dry.

Orthic - common; used in the classification of soils.

Oxic horizon - A soil horizon not exhibiting an accumulation of clays or a prismatic or columnar structure. It is at least 30 cm. thick, does not have more than traces of primary aluminosilicates and ferromagnesium minerals, and has a texture of sandy loam or finer in the fine earth fraction, and has more than 15% clay.

Sulfuric horizon - A soil horizon formed as a result of artificial drainage and oxidation of mineral or organic materials which are rich in sulfides. This horizon is characterized by a pH of less than 3.5.

Takyric - Soils with a heavy texture which crack into polygonal elements when dry and form a platy or massive surface crust.

Umbric horizon - a soil horizon having an organic matter content of from 4 to 20%, a phosphorus content of less than 250 ppm, a thickness of from 10 cm. to more than 25 cm., and having a base saturation of less than 50 percent.

* The definitions presented in this glossary were abstracted from the FAO-Unesco Soil Map of the World, Vol. 1, Legend (1974). These definitions are not complete and should be used only to distinguish between the general soil characteristics discussed in this report.

APPENDIX 3. SALINITY AND THE CLASSIFICATION OF IRRIGATION WATER

The following figure is a nomogram used to classify irrigation water on the basis of electrical conductivity (EC) (a measure of total dissolved solids) and sodium-absorption-ratio (SAR) (a measure of dissolved sodium). To use this nomogram, the EC in micromohms/cm is located along the bottom (X) axis, and the SAR is located on the left (Y) axis.

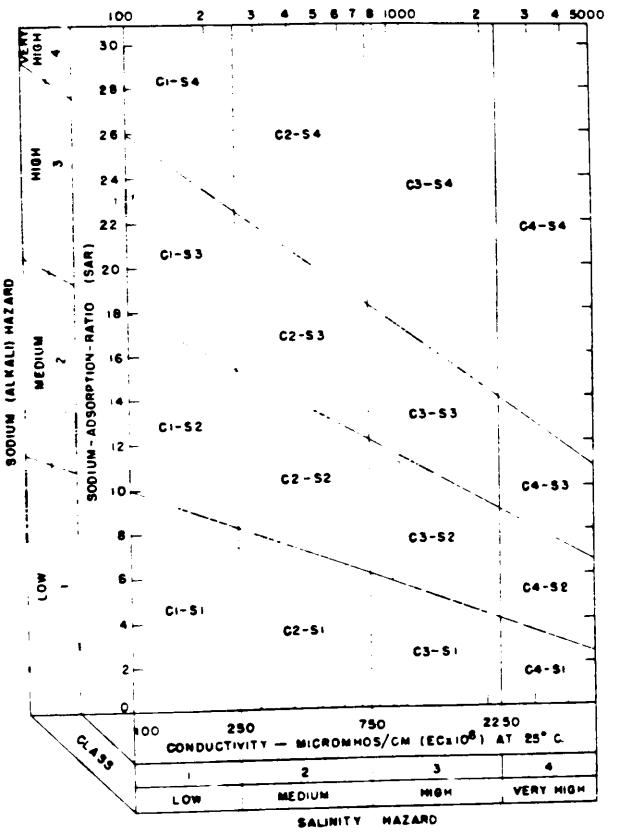

Fig. 12. Nomogram for the classification of irrigation water

The intersection of lines drawn perpendicular to their respective

axes from the previously determined values will fall within a labeled zone. Each zone corresponds to a classification of the total salinity and alkalinity of the irrigation water and it suitability for irrigation. The significance and interpretation of these classifications is summarized below.

1. Salinity Classification.

C1—LOW SALINITY WATER can be used for irrigation with most crops on most soils, with little likelihood that a salinity problem will develop. Some leaching is required, but this occurs under normal irrigation practices except in soils of extremely low permeability.

C2—MEDIUM SALINITY WATER can be used if a moderate amount of leaching occurs. Plants with moderate salt tolerance can be grown in most instances without special practices for salinity control.

C3—HIGH SALINITY WATER cannot be used on soil with restricted drainage. Even with adequate drainage, special management for salinity control may be required, and plants with good salt tolerance should be selected.

C4—VERY HIGH SALINITY WATER is not suitable for irrigation under ordinary conditions but may be used occasionally under very special circumstances. The soil must be permeable, drainage must be adequate, irrigation water must be applied in excess to provide considerable leaching, and very salt-tolerant crops should be selected.

2. Sodium Classification.

S1—LOW SODIUM WATER can be used for irrigation on almost all soils, with little danger of the development of a sodium problem. However, sodium-sensitive crops, such as stone-fruit trees and avocados, may accumulate injurious amounts of sodium in the leaves.

S2—MEDIUM SODIUM WATER may present a moderate sodium problem in fine-textured (clay) soils unless there is gypsum in the soil. This water can be used on coarse-textured (sandy) or organic soils that take water well.

S3—HIGH SODIUM WATER may produce troublesome sodium problems in most soils and will require special management—good drainage, high leaching, and additions of organic matter. If there is plenty of gypsum in the soil, a serious problem may not develop for some time. If gypsum is not present, it or some similar material may have to be added.

S4—VERY HIGH SODIUM WATER is generally unsatisfactory for irrigation except at low- or medium-salinity levels where the use of gypsum or some other amendment makes it possible to use such water.

Table 18. Classification of irrigation water.

The EC and SAR values determined from the ONERN (1973) analysis of

water from the Toma Ascope have been used to illustrate this procedure. The results for all ten of the samples analyzed by ONERN (1973 (II):91) are presented in the table below.

TABLE 19 . Summary of Water Samples Analyzed by ONERN (1973).*

Sample Number	Location	pH	Cation Exchange (mmhos/cm.)	Cations (meq/lt.)				Sum of Cations	Anions (meq/lt.)					Sum of Anions	SAR	Boron (p.p.m.)	Classification
				Ca	Mg	Na	K		CO_3	HCO_3	NO_3	SO_4	Cl				
1	Puente Moreno	7.8	0.53	3.3	1.35	0.85	0.04	5.5	0.0	2.8	0.0	1.9	0.8	5.5	0.5	0.14	C2S1
2	Toma Pampa de Jaguay	7.8	0.50	3.0	1.35	0.80	0.04	5.1	0.0	2.2	0.0	2.2	0.7	5.1	0.5	0.12	C2S1
3	(El Salinar)	7.8	0.50	3.1	1.35	1.00	0.04	5.4	0.0	2.4	0.0	2.4	0.6	5.4	0.6	0.11	C2S1
4	Toma Sausal	7.8	0.61	3.7	1.55	1.20	0.04	6.4	0.0	2.8	0.0	3.0	0.6	6.4	0.7	0.10	C2S1
5	Medidor Sausal	7.8	0.51	3.0	1.35	0.90	0.04	5.2	0.0	2.5	0.0	2.1	0.6	5.2	0.9	0.16	C2S1
6	Toma Ascope	7.8	0.51	3.2	1.35	0.80	0.04	5.3	0.0	2.5	0.0	2.2	0.6	5.3	0.5	0.15	C2S1
7	Toma Paijan	7.8	0.53	3.3	1.40	0.90	0.04	5.6	0.0	2.5	0.0	2.6	0.5	5.6	0.6	0.14	C2S1
8	Toma Toma	7.8	0.53	3.3	1.35	0.90	0.04	5.7	0.0	2.8	0.0	2.4	0.5	5.7	0.6	0.13	C2S1
9	Toma Chiclin	7.9	0.53	3.2	1.40	0.90	0.04	5.5	0.0	2.5	0.0	2.4	0.6	5.5	0.6	0.12	C2S1
10	Toma Cartavio	7.7	0.80	4.9	1.90	1.10	0.04	7.0	0.0	3.6	0.0	3.6	0.8	7.9	0.6	0.14	C3S1

NOTE: The samples were taken between August 12th and 14th, 1971.
* Adapted from ONERN (1973: Cuadro no.5, page 91).

APPENDIX 4. THE DETERMINATION OF NATURAL LIFE ZONES FROM CLIMATIC AND ALTITUDINAL DATA.

The procedure for determining the correct life zone, using the nomograph reproduced here as Figure 13 , has been described by Holdridge (1967:28-29):

> In order to determine from climatic data to which life zone a particular site belongs only the mean annual biotemperature, the mean annual precipitation and the elevation above sea level are needed. The biotemperature logarithmic scales are in vertical columns at both the right hand and left hand edges of the figure in half degree intervals from 1.5° to 10° and beyond that at one degree intervals. By placing a straight edge across the chart from the correct value in each of the vertical temperature scales the line of biotemperature is located.
>
> Next, the same is done utilizing the precipitation scales at the bottom and at the right of the block of hexagons. The precipitation scales vary from intervals of 25 mm. at the drier end to much larger intervals at the wetter end. The point where such a line drawn between the precipitation values crosses the established biotemperature line for a given point is the location of that specific site on the life zone diagram. The potential evapotranspiration ratio value could be calculated also and a line drawn between its value on the corresponding scales at the left and the bottom, but this is not necessary as only two lines of crossing are needed to determine the precise location of the site being plotted.
>
> Even with the location of a point within one of the hexagons, the correct life zone is still not determined. Because the chart represents a three dimensional figure, it is still necessary to define the life zone as belonging to the basal portion of the region at the left or to an altitudinal belt at the right of one of the warmer regions.

By locating the intersection of lines drawn perpendicular to the values of temperature and elevation on Figure 13, the region is automatically determined. Two life zones which occur in the lower Chicama Valley have been plotted to illustrate the use of these momographs. The climatic data for these zones is from ONERN (1967) and is summarized in Table 7.

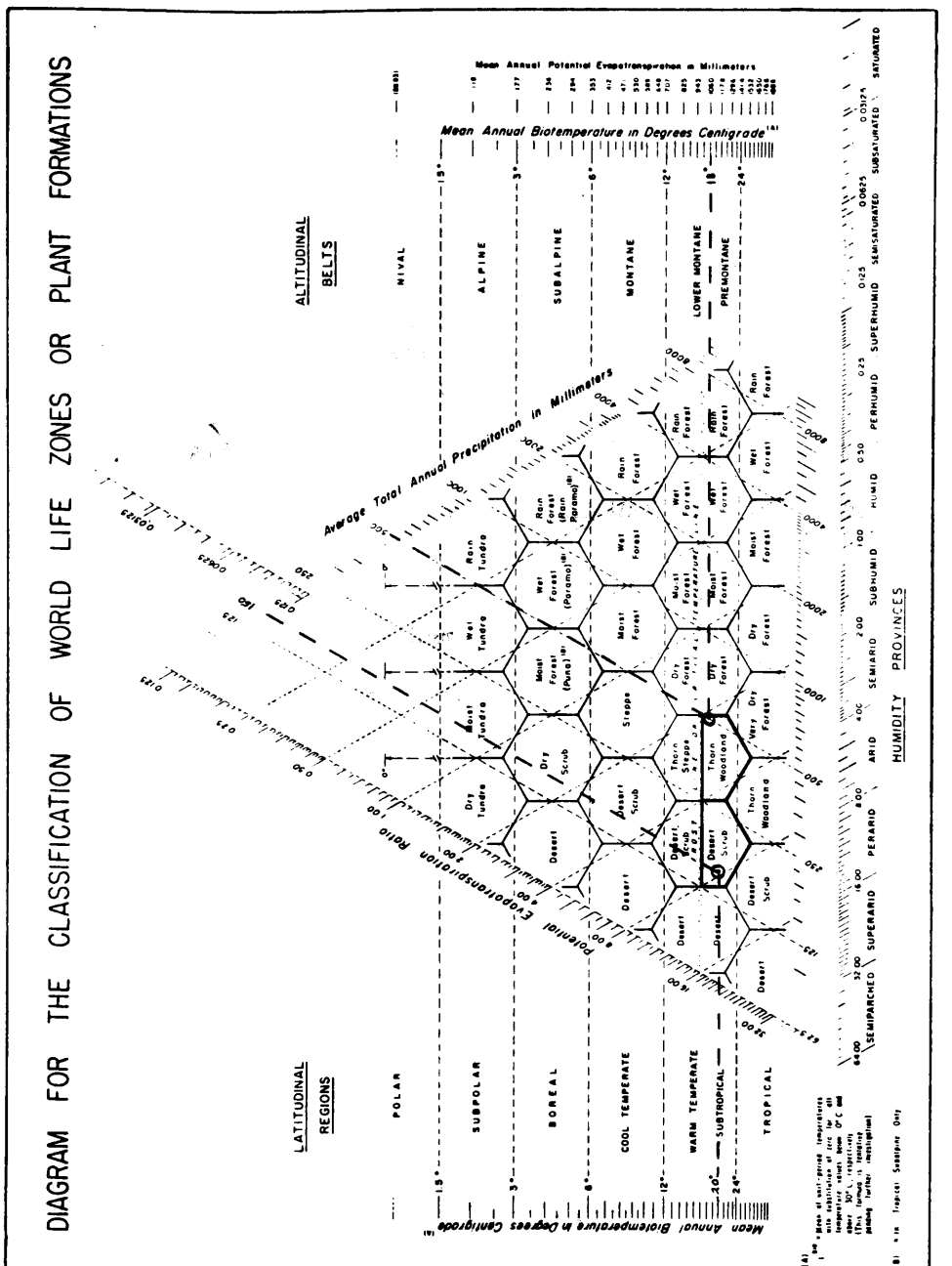

Figure 13. Plot of climatic data for two Life Zones found in the lower Chicama Valley, Peru. Adapted from Holdridge (1967:figure 1).

APPENDIX 5. SUMMARY OF ARCHAEOLOGICAL SITES ILLUSTRATED ON MAPS 3 AND 4.

Site Number: 17 Site Name: Jaguay

Location: Latitude 7°37'55" South; Longitude 78°56'40" West

Description: Terraced stone and conical adobe pyramid with associated adobe structures, stone walls, cemeteries, and petroglyphs located on prehistoric road along high terrace on the north bank of the Rio Chicama. The site is located approximately 1½ kilometers west of the confluence of the Rio San Benito and the Rio Chicama.

Cultural Affiliation(s): Salinar?, Middle Horizon

References: Kluge, Rabinowitz, and Watson (1976); Pozorski, T. (1976); Watson and Kluge (1978).

Site Number: 52 Site Name: Cerro Botija

Location: Latitude 7°42'20" South; Longitude 79°3'50" West

Description: Stone and adobe ceremonial/administrative structure, associated adobe structures, cemeteries, tombs, and stone walls on a small cerro north of Hacienda Pampas de Ventura*.

Cultural Affiliation(s): Gallinazo?, Mochica?, Middle Horizon?, Chimu.

References: Kluge, Rabinowitz, and Watson (1976); Watson and Kluge (n.d.).

Site Number: 53 Site Name: Ascope Viejo

Location: Latitude 7°41'40" - 7°42'20" South; Longitude 79°5'20" - 79°4'30" West

Description: An extensive area containing a rectangular adobe compound (approximately 112 x 68 meters), small huacas, habitation areas, cemeteries, canals, and fields. The site is bounded on the west by Cerro Ascope, on the north by Cerro Fajado, on the east by Cerro San Antonio, and on the south by the

Ascope road and modern cultivation.

Cultural Affiliation: Middle Horizon?

References: Kosok (n.d.); Kluge, Rabinowitz, and Watson (1976); Watson and Kluge (1978).

Site Number: 54 Site Name: La Laguna

Location: Latitude 7°42'10" - 7°43'10" South; Longitude 79°7'50" - 79°8'40" West

Description: An extensive area containing stone walled compounds, cemeteries, habitation areas, canals, and fields. The site is located to the north and east of the Ascope Aqueduct, approximately 2½ to 3 kilometers west of the town of Ascope.

Cultural Affiliation(s): Mochica, Middle Horizon?, Chimu?

References: Kosok (n.d.); Kluge, Rabinowitz, and Watson (1976); Watson and Kluge (1978).

Site Number: 55 Site Name: Forteleza Facala

Location: Latitude 7°43'0" South; Longitude 79°9'30" West

Description: A stone and adobe "fort" (huaca?) and associated structures on a small cerro north of Hacienda Facala.

Cultural Affiliation(s): unknown

References: Wiener (1880:108, fig.); Middendorf (1884, 2:367-368, photo 367); Muelle (1937:19-20); Larco Hoyle (1938-39: 58); Horkheimer (1944:59); Kroeber (1944:71, plate 31); Watson and Kluge (1978).

Site Number: 56 Site Name: Huaca Puckuche

Location: Latitude 7°42'34" South; Longitude 79°10'30" West

Description: Adobe huaca constructed of cane marked rectangular, conical, and truncated adobes with associated structures of rectangular adobes. This site is located approximately 3 kilometers northwest of Hacienda Facala.

Cultural Affiliation(s): Cupisnique, Mochica?

References: Larco Hoyle (1938-39:58; 1941:116, Figs. 184, 186, 187, 191); Bennett (1939:86); Kosok (n.d.).

Site Number: 57 Site Name: Unknown

Location: Latitude 7°39'45" South; Longitude 79°11'15" West

Description: This site may be a tambo and/or an administrative site for the administration of the extensive fields in which it is located. The site consists of a rectangular enclosure containing a small platform, a road, and numerous canals and fields. This site is approximately 5½ kilometers northeast of Hacienda Santa Clara in the center of the large quebrada between Cerro Tres Cerritos and Cerro San Jose.

Cultural Affiliation: Unknown

References: None

Site Number: 58 Site Name: Unknown

Location: Latitude 7°36'29" South; Longitude 79°15'52" West

Description: Another possible tambo and/or administrative site containing rectangular structures with possible storerooms located along a prehispanic road near the edge of extensive precolumbian fields. This site is about 6 kilometers north-northwest of Hacienda Mocán along the northern edge of the algarroba forest.

Cultural Affiliation: Unknown

References: None

Site Number: 59 Site Name: Ruinas de Cerro Arenilla

Location: Latitude 7°40'07" South; Longitude: 79°17'69" West

Description: An area containing rectangular enclosures, various structures, cemeteries, and a canal on the northern flanks of Cerro Pan de Azucar. The site is about 2½ kilometers east of La Arenita. Kosok (n.d.) includes this site and another approximately

2½ kilometers to the east as the Ruinas de Cerro Arenilla.

Cultural Affiliation: Unknown

References: Kosok (n.d.).

Site Number: 60 Site Name: Unknown

Location: Latitude 7°41'55" South; Longitude 79°15'14" West

Description: A relatively large site containing at least 2 huacas, rectangular enclosures, numerous associated structures, canals, fields, and several cemeteries. This site is 3½ kilometers due west of Hacienda Santa Clara along the uncultivated base of Cerro Azul.

Cultural Affiliation: Unknown

References: Kosok (n.d.).

Site Number: 61 Site Name: Unknown

Location: Latitude 7°44'45" South; Longitude 79°15'15" West

Description: This site consists of several rectangular structures, walls, and a canal which borders an area of fields on the southwestern side of Cerro Las Viudas about 2½ kilometers north of Mariposa Leyva.

Cultural Affiliation: Unknown

References: None

Site Number: 62 Site Name: Mocollope

Location: Latitude 7°46'35" South; Longitude 79°11'40" West

Description: A large complex of adobe structures located on the south and southwest flanks and base of Cerro Mocollope. This site includes several huacas, compounds, numerous rooms and walls, an irrigation canal, and several large cemeteries.

Cultural Affiliation: Mochica

References: Schaedel (1951:234); Ishida, et.al. (1960:437); Kosok (1965:108;n.d.); Watson and Kluge (1978).

Site Number: 63 Site Name: Ruinas de Malabrigo

Location: Latitude 7°40'55" South; Longitude 79°25'20" West

Description: Two adobe huacas and associated structures, cemeteries, and possible habitation areas to the north and south of the huacas. This site may be associated with a series of excavated fields to the west between the site and the coast line. The major portion of this site is located to the northeast of Puerto Chicama.

Cultural Affiliation: Unknown

References: Kosok (1965:107; n.d.); Watson and Kluge (1978).

Site Number: 64 Site Name: Puncal (Juncal)

Location: Latitude 7°43'30" South; Longitude 79°23'18" West

Description: Rectangular adobe compound and associated rooms located approximately 3/4 of a kilometer northeast of Puncal.

Cultural Affiliation: Middle Horizon?

References: Kosok (n.d.).

Site Number: 65 Site Name: Huaca Pulpar

Location: Latitude7°48'30" South; Longitude79°22'46" West

Description: A midden mound located approximately 1½ kilometers south of Milagro

Cultural Affiliation: Preceramic

References: Muelle (1937:19-20); Bird (1948:55, fig. 4); Kosok (n.d.).

Site Number: 66 Site Name: Huaca Cantagallo

Location: Latitude 7°48'40" South; Longitude 79°16'56" West

Description: A major adobe huaca with several associated smaller huacas located approximately 1 kilometer northwest of Hacienda Salamanca

Cultural Affiliation: Unknown

References: Muelle (1937:19-20); Larco Hoyle (1938-39:58); Kosok (n.d.).

Site Number: 67 Site Name: Huaca Rosario

Location: Latitude 7°50'40" South; Longitude 79°13'30" West

Descriptions: A large adobe huaca located west of Rosario. According to Kosok (1965:108), this huaca may have been associated with four nearby huacas to form a major huaca complex. This is the tallest huaca on the north bank.

Cultural Affiliation: Mochica?

References: Larco Hoyle (1938:58); Kosok (1965:109, fig. 33; n.d.); Watson and Kluge (1978).

Site Number: 68 Site Name: Huaca Prieta

Location: Latitude 7°55'5" South; Longitude 79°18'20" West

Description: A large, flat-topped, roughly oval preceramic to ceramic midden measuring approximately 125 meters long by 50 meters wide by 12 meters thick. This site, has provided some of the earliest evidence of agriculture in the New World (Bird 1948). Huaca Prieta is located on the southern tip of a low (10-15 meters) triangular plateau along the beach line, approximately 2 kilometers west of Hacienda Nazareno.

Cultural Affiliation(s): Preceramic-Cupisnique

References: Kroeber (1930); Bennett (1939); Larco Hoyle (1938-39); Bird (1948); Kosok (1965; n.d.); Watson and Kluge (1978).

Site Number: 69 Site Name: Pampas de Jaguay

Location: Latitude 7°39'10" South; Longitude 78°56'20" West

Description: A terraced hillside settlement of stone foundations with a complex of adobe huacas at the base of the cerro. A large adobe huaca, Huaca Campana (Ubelodde-Doering 1967), is located on the side of the cerro which also contains fortification walls and cemeteries. This site is located immediately to the east and northeast of Hacienda Pampas de Jaguay.

Cultural Affiliation: Mochica

References: Ubbelohde-Doering (1967); Kosok (n.d.); Kluge, Rabinowitz, and Watson (1976); Watson and Kluge (1978).

Site Number: 70 Site Name: Pelenque

Location: Latitude 7°43'00" South; Longitude 78°58'52" West

Description: A habitation area on the sides of a steep quebrada approximately 3 kilometers northeast of Hacienda Sausal. A short section of parallel adobe walls is located about midway up the side of the quebrada, and a stone fortification (?) wall runs along the ridge to the north and east of the site.

Cultural Affiliation: Middle Horizon?

References: Kluge, Rabinowitz, and Watson (1976).

Site Number: 71 Site Name: Unknown

Location: Latitude 7°44'25" South; Longitude 79°2'37" West

Description: An extensive area of habitation on several fortified cerros 4 kilometers west of Hacienda Sausal. The site also contains a portion of the Intervalley Canal and several large walls.

Cultural Affiliation: Unknown

References: None

Site Number: 72 Site Name: Unknown

Location: Latitude 7°49'45" South; Longitude 79°8'20" West

Description: Site located on cerros above Hacienda Chicamita. This site consists of a large rectangular enclosure, associated structures, habitation areas, walls, numerous canals, walls, and fields.

Cultural Affiliation: Unknown

References: None

Site Number: 73 Site Name: Chicamita

Location: Latitude 7°51'35" South; Longitude 79°8'10" West

Description: A complex of rectangular adobe compounds and associated structures.

Cultural Affiliation: Unknown

References: Schaedel (1951:233,235); Kosok (n.d.)

Site Number: 74 Site Name: Quebrada de Oso

Location: Latitude 7°51'20" South; Longitude 79°6'11" West

Description: This site consists of an area of fields with several associated structures located along the Intervalley Canal approximately 5 kilometers east-southeast of the Pueblo Chicama.

Cultural Affiliation: Chimu

References: Kus (1972); Keatinge and Day (1963).

Site Number: 75 Site Name: Chiquitoy Viejo

Location: Latitude 7°54'44" South; Longitude 79°11'0" West

Description: This site includes a rectangular adobe compound 300 x 250 meters, walls, cemeteries, a walled road, canals, fields, and associated adobe structures. Chiquitoy Viejo is located about 2½ kilometers northeast of Hacienda Chiquitoy.

Cultural Affiliation(s): Chimu?, Chimu/Inca

References: Pacheco (1926); Kroeber (1930); Larco Hoyle (1938-39); Schaedel (1951); Ishida et. al. (1960); Kosok (1965; n.d.); Conrad (1977); Watson and Kluge (1978).

Site Number: 76 Site Name: Huaca Colorado

Location : Latitude 7°55'40" South; Longitude 79°10'0" West

Description: Large adobe huaca with attached rectangular walled enclosure.

Cultural Affiliation: Unknown

References: Muelle (1937:19-20); Larco Hoyle (1938-39:58); Ishida et. al. (1960:436); Kosok (1965:110, fig. 36); Watson and Kluge (1978).

Site Number: 77 Site Name: Huaca Pan de Azucar

Location: Latitude 7°52'32" South; Longitude 79°12'22" West

Description: A steep rounded adobe huaca located approximately 1½ to 2 kilometers northeast of Hacienda Cartavio.

Cultural Affiliation: Mochica?

References: Kroeber (1930:86); Larco Hoyle (1938-39:58); Kosok (1965;n.d.).

Site Number: 78 Site Name: Unknown

Location: Latitude 7°57'5" South; Longitude 79°15'42" West

Description: An area containing several huacas and associated structures. It is briefly described by Kroeber: "Below Colpán, on the beach between Santiago and the river mouth, several small mounds or huacas are reported to contain black pottery; that is, to be late Chimu (1930:86)."

Cultural Affiliation: Chimu?

References: Kroeber (1930:86).

Site Number: 79 Site Name: Unknown

Location: Latitude 7°41'45" South; Longitude 79°10'34" West

Description: This site is a large rectangular enclosure (approximately 54.75 x 71.25 meters) which contains a small huaca or burial platform with an adjacent elevated platform. The structure has been bisected by a canal (modern?) which passes through the huaca and elevated platform. The site is located approximately 3½ kilometers northwest of Hacienda Facala.

Cultural Affiliation: Unknown

References: None

Site Number: 80 Site Name: Unknown

Location: Latitude 7°38'17" South; Longitude 79°13'47" West

Description: A large rectangular enclosure (approximately 78.75 x 67.95 meters). This structure is directly aligned with a prehistoric road which passes through the western part of the Pampa de Mocan. This site may therefore be a tambo and/or a center for the distribution of the agricultural products raised in the Mocan fields. The site is approximately 1-3/4 kilometers northeast of Hacienda Mocan.

Cultural Affiliation: Unknown

References: None

*References to haciendas and other place names are made in accordance with the Chocope (1973), Otuzco (1970), Trujillo (1974), and Salaverry (1975) sheets of the Carta Nacional 1:100,000 of the Instituto Geografico Militar, Lima, Peru.

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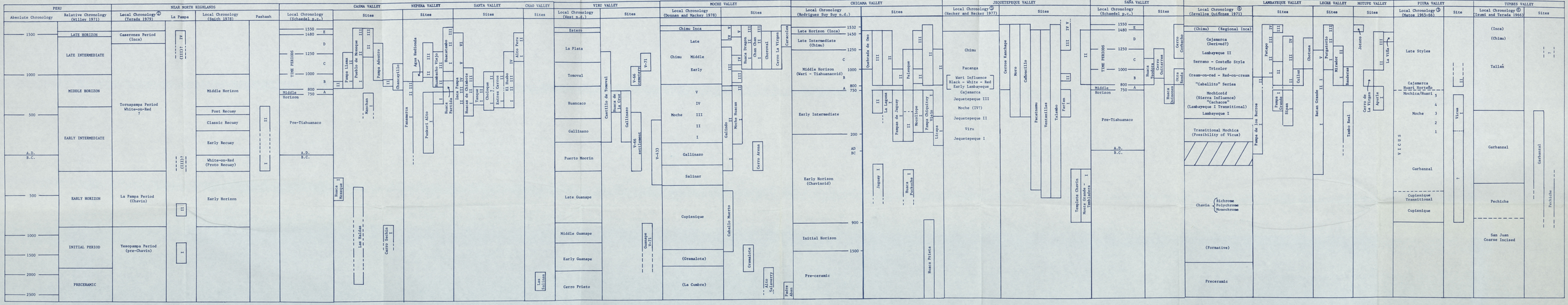
Table 1. Chronological chart and selected archaeological sites of the North Coast and near North highlands of Peru [1]



[1] Much of the archaeological evidence used in the temporal placement of sites on the North Coast is based on a settlement pattern study conducted by R.P. Schaedel, 1952-55.

[2] Local chronology adapted from period descriptions and data presented by Terada (1979).

[3] Local chronology adapted from the ceramic sequence presented by Hecker and Hecker (1977) which was derived from burials excavated by Ubbelohde Doering at the site of Pacatnamu.

[4] Local chronology adjusted on the basis of recent radiocarbon dates from the site of Pampa Grande (see Table 2).

[5] Local chronology adapted from evidence presented by Matos (1965-66).

[6] Local chronology adapted form period designations and data presented by Izumi and Terada (1966).

Map 4. Map of soils and selected archaeological sites and features in the lower Chicama Valley, Peru.

GREAT SOIL GROUPS (FAO 1974)

Fe(i)	EUTRIC FLUVISOLS (IRRIGATED)	Re	REGOSOLS
Fe(un)	EUTRIC FLUVISOLS (UNIRRIGATED)	Re Sg	REGOSOLS AND SOLANCHAKS
Sg	GLEYIC SOLANCHAKS	So	ORTHIC SOLANCHAKS
	Ld DESERTIC LITHOSOLS		

EXPLANATION OF SOILS SYMBOLS

Ld-c — SOIL GROUP ASSOCIATION
Ld-c — DOMMINANT CLASS OF RELIEF
8/7 — SECONDARY USE CLASSIFICATION
8/7 — DOMINANT USE CLASSIFICATION

CLASSES OF RELIEF

a	LEVEL TO ROLLING
b	HILLY
c	MOUNTAINOUS

CLASSES OF CAPACITY FOR USE

TYPE OF AGRICULTURE	CLASS	TYPE OF AGRICULTURE	CLASS
INTENSIVE	1	PERMANENT	5
	2		6
	3	MARGINAL	7
	4	USELESS	8

ARCHAEOLOGICAL SITES AND FEATURES

SITES ■ IRRIGATION CANALS ROADS

EXCAVATED FIELDS

TYPE 1 TYPE 2

ARCHAEOLOGICAL SITE NUMBERS AND NAMES*

17	Jaguay	66	Huaca Cantagallo
52	Cerro Botija	67	Huaca Rosario
53	Ascope Viejo	68	Huaca Prieta
54	La Laguna	69	Pampas de Jaguay
55	Forteleza Facala	70	Pelenque
56	Huaca Puchuche	71	unknown
57	unknown	72	unknown
58	unknown	73	Chicamita
59	Ruinas de Cerro Arena	74	Quebrada de Oso
60	unknown	75	Chiquitoy Viejo
61	unknown	76	Huaca Colorado
62	Mocollope	77	Huaca Pan de Azucar
63	Ruinas de Malabrigo	78	unknown
64	Puncal (Juncal)	79	unknown
65	Huaca Pulpar	80	unknown

*Site numbers are a continuation of a series begun in the central Chicama Valley by Richard P. Watson and Margaret J. Kluge.

N

SCALE 1:100,000

5 0 5

10 KILOMETERS

THIS MAP WAS COMPILED FROM MAPA 3: MAPA DE GRANDES GRUPOS DE SUELOS Y DE CAPACIDAD DE USO – 1:200,000 (ONERN 1973a) AND MAPA 3: MAPA DE GRANDES GRUPOS DE SUELOS Y DE CAPACIDAD DE USO – 1:200,000 (ONERN 1973b).

RIVERS INTERMITANT DRAINAGES

Map 3. Map of selected archaeological sites and features in the lower Chicama Valley, Peru.

ARCHAEOLOGICAL SITES AND FEATURES

SITES ■ IRRIGATION CANALS ROADS

EXCAVATED FIELDS

TYPE 1 TYPE 2

ARCHAEOLOGICAL SITE NUMBERS AND NAMES*

17	Jaguay	66	Huaca Cantagallo
52	Cerro Botija	67	Huaca Rosario
53	Ascope Viejo	68	Huaca Prieta
54	La Laguna	69	Pampas de Jaguay
55	Forteleza Facala	70	Pelenque
56	Huaca Puchuche	71	unknown
57	unknown	72	unknown
58	unknown	73	Chicamita
59	Ruinas de Cerro Arena	74	Quebrada de Oso
60	unknown	75	Chiquitoy Viejo
61	unknown	76	Huaca Colorado
62	Mocollope	77	Huaca Pan de Azucar
63	Ruinas de Malabrigo	78	unknown
64	Puncal (Juncal)	79	unknown
65	Huaca Pulpar	80	unknown

*Site numbers are a continuation of a series begun in the central Chicama Valley by Richard P. Watson and Margaret J. Kluge.

AREA OF MODERN CULTIVATION

SCALE 1:100,000

5 0 5

10 KILOMETERS

PROJECTION: TRANSVERSE MERCATOR

UTM ZONE: 17

CONTOURS AT 200 METER INTERVALS WITH SUPPLEMENTARY CONTOURS EVERY 50 METERS FROM SEA LEVEL TO 250 METERS

THIS MAP WAS COMPILED FROM THE CHOCOPE, OTUZCO, TRUJILLO, AND SALAVERRY SHEETS OF THE CARTA NACIONAL 1:100,000 OF THE INSTITUTO GEOGRAFICO MILITAR. LIMA, PERU.

RIVERS INTERMITANT DRAINAGES

N

7° 30′ S
9168 N
9164
9160
9156
7° 40′
9152
9148
9144
9140
9136
7° 50′
9132
9128
9124
9120
9116
8° 00′
9112
9108
9104
9100 N
8° 10′ S

79° 30′ W 672 676 680 79° 20′ 684 688 692 696 79° 10′ 700 704 708 712 716 79° 00′ 720 724 728 732 736 78° 50′ W 740 E